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AIRCREW COMBAT PREPARATION TRAINING

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This report has been reviewed and is approved for publication.

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This report is the result of a US Air Force-sponsored study to forecast future technologies and systems required for optimally conducting aircrew ancillary training in the next century. The study findings are based on the review of regulations, documents and related publications, and on the interviews of nearly 50 pilots, instructor pilots, and training personnel at Tactical Air Force Major Commands, fighter wings, and air warfare centers.

This volume provides a comprehensive description of the existing US Air Force Aircrew Combat Preparatory Training system and an assessment of that system's operations. It also forecasts future operational requirements and their impact and identifies areas of concern. Long term training needs are defined from these areas of concern and suggested courses of action are discussed. A developmental roadmap is included that describes the actions necessary to resolve any technology shortfalls.

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1.0 INTRODUCTION

1.1 Background

For many years the United States (U.S.) maintained a significant lead in weapon system capability over its potential enemies because of a superior technology base. This technological advantage was relied upon to balance a numerical disadvantage. This situation was certainly true of the aircraft, weapons and support systems associated with the conduct of air combat. In more recent years, the technology lead enjoyed by the U.S. has been shrinking in a number of key technology areas such as materials, aerodynamics, propulsion, electronics and computers. Consequently, the weapon systems (both airborne and ground-based) which United States Air Force (USAF) aircrews could face in combat are becoming increasingly sophisticated and capable. In addition, these more capable weapons are no longer limited to the major powers but are appearing in large numbers in smaller and perhaps less stable countries. The decreasing technological superiority of U.S. weapon systems presents an increasing challenge to the aircrew in maintaining air combat dominance.

Preparing an aircrew for combat is a complex and demanding task. The aircrew must not only be skilled at controlling the aircraft and using its systems, but must also be ready to deal with a large number of decisions associated with their employment. To perform in a combat environment effectively, the aircrew must know threat capabilities, limitations and operating characteristics, and the best tactics to use against them. The aircrew must comprehend numerous peacetime and wartime theater operating procedures, as well as potentially complex rules of engagement. The aircrew must clearly understand the use of specialized protective equipment for operating in nuclear, biological and chemical environments and the degrading effect of the use of this equipment on aircrew performance and tactics. Knowing and understanding this vast amount of information is not enough; the aircrew must be able to apply it in making critical decisions in the highly-dynamic, time-stressed combat environment.

The operational unit is largely responsible for preparing the aircrew for combat. While preparing and maintaining combat ready aircrews is an increasingly difficult task, many of the resources available to the operational units for accomplishing the necessary training are becoming scarcer.

The Human Systems Division (HSD) of the Air Force Systems Command (AFSC) is responsible for conducting training research and developing USAF training systems which are not for specific weapon systems. To ensure the most effective use of the limited resources available to HSD, the Deputy For Development Planning (XR) initiated a study of aircrew combat preparation training. QuesTech, Inc. conducted the study under contract F33615-87-D-O661, Task Order 003.

1.2 Study Objectives

The objectives of this study were: 1) to identify potential problems in accomplishing aircrew combat preparation training and 2) to recommend training system research and development (R&D) programs which could alleviate them. The results of this study will provide guidance for program development and advocacy within the AFSC laboratory and system development organizations.

1.3 Study Scope

All pilots and navigators progress through a number of training stages before becoming combat-ready crew members. Figure 1.1 illustrates the training stages experienced by a tactical fighter pilot. Tactical combat training begins with undergraduate pilot training (UPT), progresses through lead-in fighter training (LIFT), initial qualification training (IQT), and continues indefinitely as mission qualification training (MQT) and continuation training (CT) after assignment to an operational unit. The dashed lines on Figure 1.1 show figuratively how the emphasis of the training shifts from systems operation to systems employment. This study focused on the systems employment training of aircrews assigned to operational units. This training includes MQT and CT as depicted by the shaded area in Figure 1.1. It also includes specialized training (ST) performed by the operational unit. The study is limited to the training of aircrews assigned to the Tactical Air Forces (TAF) and the Special Operations Forces (SOF).

In the conduct of this study, it was necessary to examine both current operations and training methods to establish a baseline from which projections of operational environments and training requirements could be made. This study is not an attempt to evaluate the overall effectiveness of combat preparation training today.

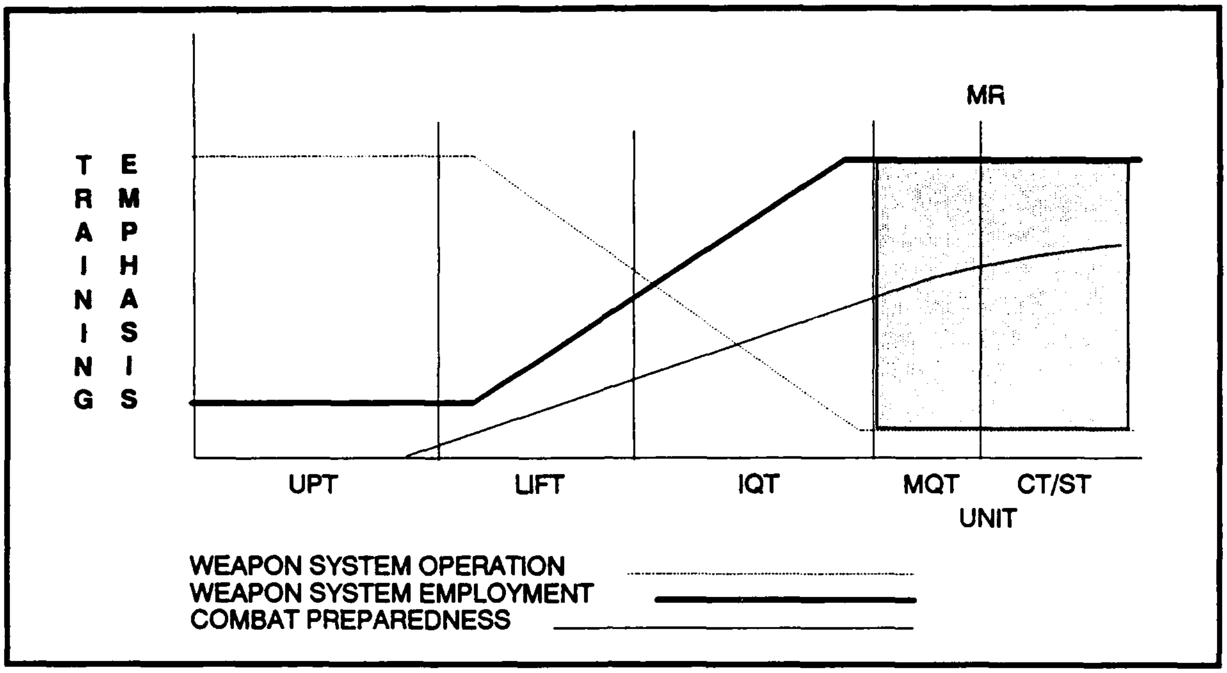

Figure 1.1 - Combat preparation training stages.

2.0 METHODS

Figure 2.1 provides a view of the steps taken to achieve the study objectives. The following discussions describe the accomplishment of each of these steps.

2.1 Data Collection

2.1.1 Current Combat Operations

The examination of current combat operations involved a review of AFM 1-1, "Functions and Basic Doctrine of the USAF;" AFM 3-1, "Tactical Air Command Doctrine;" and TACM 3-3, "Tactical Air Command Tactics." This review included an examination of the USAF tactical missions of Counter Air, Air Interdiction, Close Air Support, Special Operations and Aerospace Surveillance and Reconnaissance. The review covered the threat, basic doctrine, mission and organization of the tactical air forces. Emphasis was placed on the command and control structure, systems and' procedures used to successfully employ tactical air forces. Finally, this examination of current operations addressed the functions and responsibilities of the Tactical Air Control Center (TACC) which is responsible for tasking all tactical air operations.

2.1.2 Current Combat Preparation Training

A review of training regulations and a series of interviews were conducted to determine how combat preparation training is currently accomplished within the assigned operational units. To ensure that appropriate information was collected and that the resulting data could be efficiently stored and analyzed, interview data collection sheets were developed. The data collection process was structured to capture general comments and opinions as well as specific data. To facilitate data collection and to enhance data analysis, the interviewee was provided menus of possible responses. Examples of the data collection sheets and response menus are in Appendix B.

The following concepts and terms were defined to ensure a common understanding of the interview questions. These definitions were developed after reviewing training regulations and technical literature and then refined through discussions with training personnel.

2.1.2.1 Training Areas

Training areas are general groupings of training subjects which have common characteristics. Tactical Air Command (TAC) Manual 51-50, "Tactical Aircrew Training," and the course syllabi outline a large number of general and specific training subjects and group them in a variety of ways. The total number of training subjects,

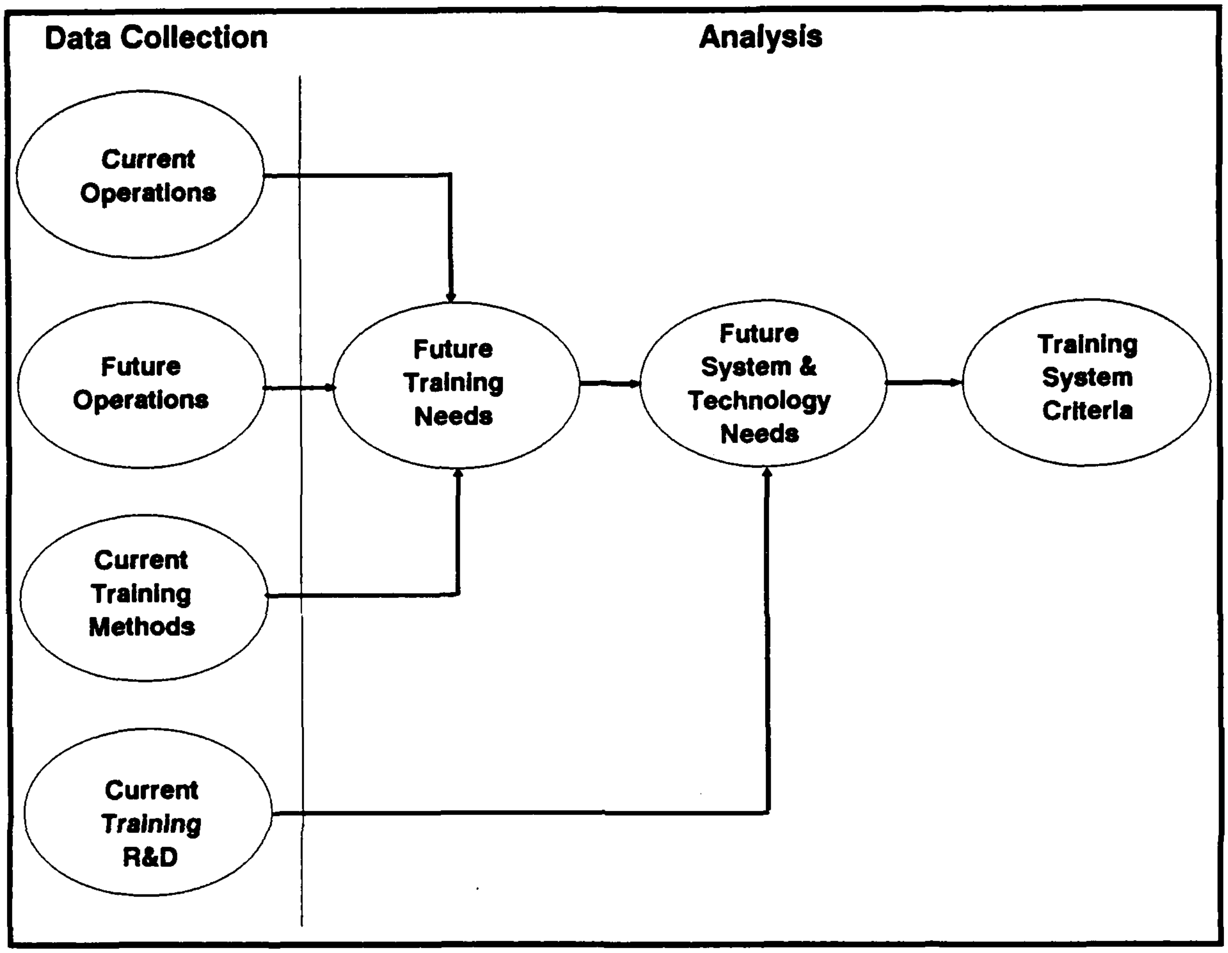

Figure 2.1 - Combat training study methodology

the variety of subject groupings and the overlap between groupings required that a set of training areas be defined for this study. The following training area definitions were used.

o Weapons Employment Training includes those subjects dealing specifically with arming and delivering a weapon.

o Theater Operations Training includes those subjects which provide the aircrew with the necessary procedural knowledge and decision criteria to enable efficient, safe operations within the theater. This training includes operations within friendly airspace prior to penetration and following return from enemy airspace or initiation of an attack against a target.

o General Mission Training deals with those subjects required to fly one or more aircraft from friendly airspace to the point of weapons delivery. This training area includes a wide array of activities such as low altitude flight techniques, air-to-air intercept procedures, and air combat maneuvers (ACM).

o Mission Support Training includes a variety of subjects which prepare the aircrew for combat but does not include specific actions involving the aircraft. Examples of this type of training include escape and evasion techniques; Nuclear, Biological and Chemical (NBC) procedures; threat system characteristics; enemy tactics; and electronic combat (EC) techniques.

o General Flight Training includes those subjects addressing general piloting skills which include cross-country navigating, landing, taking off, and instrument flying.

2.1.2.2 Content Volatility

Content volatility refers to the frequency with which changes occur in training materials which must be assimilated within a training area. Changes can be caused by many factors, e.g., updated intelligence data, and may require the aircrew to alter previously acquired information or to learn totally new material. Since the definitions of the training areas are very general, each area includes a wide variety of specific subjects. Content volatility is a general characteristic of a training area, and is not necessarily descriptive of each specific subjectin he training area.

2.1.2.3 Content Complexity

Content complexity refers to the relative difficulty of describing and understanding concepts within a given training area. Abstract or highly technical concepts are more complex than procedural concepts which require only memorization and recall. As with content volatility, content complexity is a general characteristic of a training area, and does not necessarily apply to each specific topic within the training area.

2.1.2.4 Training Phases

Training phases categorize specific learning objectives. A review of Multi-Command Manual (MCM) 51-50 and Air Force Manual (AFM) 50-2, "Instructional Systems Development," provides a number of different ways to describe and group specific learning objectives. For the purposes of this study, learning objectives are grouped into the three phases described below.

0 Knowledge refers to that phase of training in which factual information is transferred. During this phase of training, the aircrew member is provided the necessary information to accomplish a required task. Examples of factual information include system descriptions, limitations, capabilities, procedures, and warnings.

0 Decision-making refers to that phase of training which teaches the aircrew to assess a given situation and select an appropriate response. The decision-making phase develops the aircrew member's ability to use the basic information acquired during the knowledge phase. Analysis techniques, decision rules, rules-of-thumb, and priorities are some of the topics which would be addressed in this training phase.

0 Implementation refers to that phase of training in which the aircrew member learns and refines the motor response skills required to accomplish a desired action, e.g., manipulating the flight controls or selecting a fire control setting. This phase of training enhances the aircrew member's ability to perform required actions resulting from tactical decisions made during flight.

2.1.3 Training Research and Development

The assessment of current and planned development programs in training technology and methodology involved an extensive review of government reports and other literature sources. During this review, an opportunity arose to attend the 1988 Interservice/Industry Training Systems Conference. Attending presentations and reviewing the subsequent proceedings was a valuable source of data on current training R&D trends. The Defense Technical Information Center (DTIC) on-line access system was used to review government documents. Information was also gathered by personal interviews with USAF training researchers. This information was compiled to create a description of current technology and current/planned technology development programs.

2.1.4 Future Combat Operations

Desired future combat capabilities were derived through a review of Requirements Identification and Technology Assessment Summaries (RIATAS) which were produced by HSD/XR. These summaries provide a description of future operational and system environments. The projections are based on a review of planning documents developed at the major using commands, Headquarters AFSC, and Headquarters USAF. These projections are then coordinated with the appropriate major commands. The specific RIATAS documents reviewed deal with the Tactical Warfare, Special Operations, and Reconnaissance/Intelligence mission areas. This review identified a set of system and operational trends which will impact combat preparation training in the future.

2.2 Analysis

2.2.1 Impacts on Combat Preparation Training

A forecast of potential impacts on future combat preparation training was developed after a systematic review of system and operational trends. The impacts identified were limited to those which either amplified current training challenges or created new ones.

2.2.2 Training Systems and Technology Development Needs/Roadmap

Desired combat preparation training systems were formulated to address the identified training needs. Each system was assessed to determine the technology required for its development. Based on current technology and current/planned technology development programs, a roadmap was developed which depicted a recommended phasing of system and technology development programs.

2.2.3 Training System Criteria

In conjunction with the identification of desired combat preparation training systems, assessment criteria were developed for evaluating proposed system development programs.

3.0 DATA COLLECTION

3.1 Current Combat Operations

Tactical Air Operations span five of the nine missions identified in USAF basic doctrine: counterair, air interdiction, close air support, special operations, and surveillance and reconnaissance (Air Force Manual 1-1). The USAF typically employs tactical air operations as an element of a joint task force, providing for unified action of interdependent land, naval and air forces. The air component commander exercises control authority over air forces to ensure achievement of the primary objectives. This command arrangement exploits the speed, range, flexibility and firepower of air forces. Internally the USAF Tactical Air Control System (TACS) provides for unity of command and responsive allocation, mission planning and execution.

Each of the five USAF operational missions was evaluated to determine the types of aircraft operations required to accomplish those missions. A discussion of the missions is in Appendix A, Section A.

The Tactical Air Control Center (TACC) is the implementation organization for the Air Force TACS. A discussion of the TACC is in Appendix A, Section B.

The operational organizations were reviewed to identify locations of units, types of aircraft assigned and unique characteristics of each command. A discussion of the commands is in Appendix A, Section C.

3.2 Current Combat Preparation Training

In researching current combat preparation training, pertinent training documents were reviewed and a series of interviews were conducted. Table 3.1 provides a list of the specific organizations visited, their location and the type of aircraft flown. The interviews consisted of free flowing as well as structured discussions. The results of the structured portion of the data collection interviews are in Appendix D. Data collection visits were scheduled to obtain a good cross section of operating theaters, aircraft types and designed operational capabilities (DOCs). The following discussions of training management, training delivery and training evaluation summarize the results of this data collection activity.

TABLE 3.1 - Organizations Contacted During Data Collection

UNIT	LOCATION	AIRCRAFT
1 SOW/DOT	Hurlburt Field, FL	MC-130E, AC-130, AH-53
149 TFW (ANG)	Kelly AFB, TX	F-16A/B
26 TRW/DOT	Zweibrucken AB, GE	RF-4C
33 TFW	Eglin AFB, FL	F-I5C/D
36 TFW/DOO	Bitburg AB, GE	F-15C/D
435 TAW/DOT	Rhein Main AB, GE	C-130
52 TFW/DOT	Spangdahlem AB, GE	F-4G, F-I6C/D
59 TFS	Eglin AFB, FL	F-15C/D
7 SOS/DO	Rhein Main AB, GE	MC-130E
71 TFS	Langley AFB, VA	F-I5C/D
86 TFW/DOTT	Ramstein AB, GE	F-16C/D
HQ TAC/DOT	Langley AFB, VA	
HQ TAC/DOOF	Langley AFB, VA	
HQ PACAF/DOO	Hickam AFB, HI	
HQ USAFE/DOO	Ramstein AB,GE	
USAFTAWC/TNA	Eglin AFB, FL	
USAFTAWC/TNT	Eglin AFB, FL	

3.2.1 Training Management

MCM 51-50 Volume I, "Tactical Aircrew Training," provides general guidance on the conduct of tactical aircrew training for all TAF flying units as well as those Air National Guard and Air Force Reserve units attached to TAC. This manual contains guidelines for the conduct of ground, simulator and flying training to ensure that units maintain the capability to perform their assigned tactical mission effectively. It includes training standards and programs for initial qualification training (IQT), mission qualification training (MQT), specialized training (ST), and continuation training (CT) conducted within the unit. The manual meets unique theater training requirements through the incorporation of a Major Command specific Chapter 6, "MAJCOM Specific Guidance." Each Major Command, i.e., TAC, PACAF, AAC and USAFE, develops and maintains its own specific Chapter Six. A series of aircraft-specific volumes, e.g., Volume VIII, "F-16 Aircrew Training" supplements MCM 51-50. Although this manual provides general guidance for the conduct of tactical aircrew training, the specific content and implementation of the training program is the responsibility of the individual wings and their assigned squadrons.

Military Airlift Command (MAC) Regulation 51-130, "C-130 Aircrew Training," and Air Force Regulation (AFR) 51-2, "US Air Force Helicopter Aircrew Training," as supplemented by MAC, provide general aircrew training guidance for the Special Operations Forces (SOF). The structure and content of these regulations are similar to MCM 51-50.

Although provisions are made for the conduct of IQT at the operational unit, aircrews usually receive this training at one of the formal Replacement Training Units (RTUs) designated for this activity. The majority of the aircrew training conducted at the operational unit is MQT, ST or CT; consequently, the emphasis of the data collection was placed in these areas.

Mission qualification training primarily enhances training received at the RTU and acquaints new aircrews with specific unit and theater operations. The training consists of academic, simulator and flight events designed to upgrade the aircrew to a Mission Ready (MR) status. At any given time, approximately ten percent of the aircrew members assigned to a unit can be expected to be in this upgrade status. Once designated MR, the aircrew member is ready to perform the unit's primary mission without further training, and is considered qualified for participation in combat. The maximum length of time permitted for an aircrew member to reach MR status differs slightly by MAJCOM, type aircraft and DOC but generally ranges between 30 and 120 days following initiation of training within the unit.

Although formally designated as MR, the crew member may not be qualified in all of the unit's assigned missions or weapons. The interviewees generally felt that becoming a fully combat ready wingman requires a minimum of 6 to 18 months, depending upon the complexity of the unit's assigned mission. Consequently, USAFE has instituted a program called Tactical Aircrew Fighter Training (TACFT) which follows initial MR status and aids in the development of new aircrews. During this period, under instructor supervision, the new crew member is introduced to an expanding combat preparation environment.

Specialized training occurs after MQT at intervals throughout an aircrew's flying career. The specific timing of this type of training is not formally established but is instead based upon proficiency. Specialized training includes the training required for certification on certain weapons that a unit employs and training necessary to upgrade to higher status such as instructor, flight leader or flight examiner. Each of these programs includes some type of academic training, flight training and formal evaluation.

Continuation training constitutes the majority of training conducted within the unit. This type of training is less formal than the other types of training discussed thus far and does not generally require supervision by an instructor. This training continues throughout the aircrew member's career to heighten and maintain combat skills associated with the unit's assigned weapon systems and mission. These programs include accomplishment of academic, simulator and flight training events on a recurring schedule. The flight training events occur semi-annually while the ground and simulator training activities may have variable frequency requirements ranging from monthly to once every three years depending upon the nature of the training.

The TAF utilizes a flight training management method called the Graduated Combat Capability (GCC) program for planning and scheduling training sorties. The SOF uses a similar technique to manage CT. Both management systems are event-based rather than proficiency-based. They prescribe a minimum number of training events to be accomplished within a prescribed time period rather than prescribing graduated proficiency requirements. The basic assumption is that if an aircrew accomplishes the required number of training events and successfully completes periodic evaluations, the aircrew members will be proficient. The GCC program within the

TAF defines three levels of training designated levels A, B and C. Level A is the basic mission ready standard and prescribes the minimum training necessary for the aircrew to perform the unit's primary mission. Level B is the recommended training to increase proficiency, lower combat attrition and increase the unit's capability to meet its full tasking. Level C is the complete program for the unit, based upon its tasked mission. The MAJCOM, using input from the assigned wings, establishes the specific events and the required number of repetitions at each level. The GCC training level 'or a particular aircrew depends upon the number of sorties available to the unit, the desired distribution of training sorties within the unit, level of experience and type of job within the unit, as well as numerous other factors. The flight scheduling officer in conjunction with the training and standardization/evaluation personnel ensures that the unit's flying program fulfills the overall training objectives. This is a complex task subject to the availability of aircraft, availability of training ranges (weapons, low level, etc.), weather conditions and political restrictions. There is also a need to interact with other units to obtain required training support, such as by tankers and by airborne control aircraft.

The percentage of aircrews training at level B fluctuates considerably from unit to unit and over time, but averages approximately 70% TAF-wide. The number of aircrews training at level C is generally quite limited and may be zero in some units. As mentioned earlier, the distribution of training sorties and consequently of training levels is largely a management decision within the wing and squadron.

The unit conducts the majority of aircrew training using resources available within the unit's local training area. Local training is supplemented through participation in operational exercises conducted at many different organizational levels and geographical locations, for example, Local Salty Nation (LSN), Red Flag, Green Flag and Cope Thunder. Those interviewed considered participation in these training exercises to be extremely valuable. They reasoned that aircrew proficiency and overall combat preparedness peaks with participation in these intense training exercises. Unfortunately, participation in this type of training occurs relatively infrequently and in some cases may not include all aircrews.

As a general practice, all training sorties are as close to a combat scenario as possible. The 7th Special Operations Squadron frequently spends up to two weeks preparing for a single training sortie. They start from a mission tasking and intelligence scenario and plan the mission as if it were an actual combat mission. The Target of Opportunity Program (TOP) instituted by USAFE is another example of optimizing the combat realism of local training sorties. Within specific guidelines, any USAF aircraft operating in USAFE can attack and likewise be attacked at any time during a training mission.

Within USAFE and PACAF as well as in the SOF, aircrews frequently relocate to other air bases to accomplish required training events. These relocations can last several weeks and may occur three to four times per year. Personnel assigned to the 7th Special Operations Squadron especially depend on this type of training due to their unique flying environment. Airspace restrictions, political restrictions adverse weather conditions and a lack of specialized training ranges are the primary reasons for these trips.

3.2.2 Training Delivery

Each of the individuals interviewed provided opinions concerning the characteristics of the material and tasks associated with each of the training areas. They described the volatility (frequency of change) and the complexity (difficulty of teaching and learning) of the material to be mastered within each training area. In addition, each interviewee assessed the relative emphasis placed on each training phase and the relative difficulty of accomplishing the training objectives in each phase. Table 3.2 summarizes the results of this portion of the interview process.

The values presented are the arithmetic mean of the responses provided by the interviewees. In the evaluation of volatility and complexity, the possible responses were high, medium and low, which were given the numeric values of 1, 2 and 3 respectively. Difficulty was represented as an ordinal ranking of each training phase within a given training area. The interviewees ranked as number 1, the most difficult phase to train, while they ranked as number 3 the easiest training phase. They assessed relative emphasis by indicating the percentage of time spent on each training phase within a particular training area. For example, within the general flight training area the mean response indicated that 45 percent of training time was spent in transferring factual information, while 23 percent and 32 percent of the time was spent training decision-making and implementation skills respectively.

TABLE 3.2 General Training Characteristics

			KNOWLEDGE		DECISION-MAKING		IMPLEMENT	
AREA	VOL	CPX	%	DIF	%	DIF	%	DIF
General Flight	2.8	2.5	45	1.8 (1)	23	2.2 (3)	32	2.0 (2)
General Mission	2.3	1.5	20	2.9 (3)	30	1.7 (2)	50	1.4 (1)
Mission Support	1.7	1.5	46	2.7 (3)	31	1 4 (1)	23	1.9 (2)
Theater Ops	2.5	1.9	50	2.0 (2)	30	1.5 (1)	20	2.5 (3)
Weapon Employment	2.2	1.6	22	3.0 (3)	41	1.4 (1)	37	1.6 (2)

Note: 1. See Appendix B for additional descriptions of volatility and complexity. Possible responses were: 1 - High, 2 - Medium, 3 - Low.

2. The top number in the difficulty column for each training area is the average of the respondents' ordinal rankings. The number in the parentheses represents the ordinal ranking of the averages.

With the exception of mission support training, the interviewees considered the course material to be relatively stable. However, the general consensus was that the material was complex in all but the general flight training area. Decision-making was considered the most difficult training phase to accomplish in the majority of the training areas, but the decision-making training phase normally did not receive the greatest emphasis within the unit. To explain this paradox, the interviewees cited the difficulty of training decision making and of specific training methods and devices. They frequently stated that decision-making skills are not specifically taught; they develop from experience.

Each interviewee selected from a list of training media those most frequently used within the unit for each

1. One-on-one discussions (pre/post flight briefings).
2. Group lectures (briefings).
3. Visual aids (pictures, graphs, drawings).
4. Audio aids (tapes, records).
5. Audio-visual aids (films, video tape).
6. Regulations and manuals.
7. Programmed text/training manuals.
8. Mock-ups/actual equipment
9. Computer-aided instruction (CAI).
10. Part-task trainers/simulators (PTT).
11. Cockpit familiarization trainers/simulators (CFT).
12. Weapon system trainer (WST).
13. Operational flight trainers/simulators (OFT).
14. Flight demonstration.

TABLE 3.3 - Training Medium Codes

of the training phases within each of training area. The training medium codes are in Table 3.3. The interviewee ranked each selected training medium according to its contribution to the accomplishment of the desired training objectives. Figures 3.1, 3.3, 3.5, 3.7 and 3.9 show the distribution of interviewee responses for the primary training delivery medium for each training area. Figures 3.2, 3.4, 3.6, 3.8 and 3.10 show the cumulative interviewee responses for the primary, secondary and tertiary training delivery medium for each training area. For example, Figure 3.3 shows that five people selected training medium 1 (one-on-one discussions) as the primary method for the transfer of factual information (knowledge) within the general mission training area. The general flight training area had fewer responses than the remainder of the training areas due to time constraints during the interviews. The discussions became quite involved and lengthy at times and the interviewer felt that GFT has the least direct relationship to combat preparedness and was, therefore, frequently omitted.

3.2.2.1 Knowledge

The primary method used for the transfer of factual information was through verbal interactions in the form of group or one-on-one discussions, followed closely by written materials. In general, the written material consisted of regulations and manuals rather than specifically designed training documents. The cumulative responses for the top three rankings strongly reinforce this trend. The trend remained consistent within each of the individual training areas.

The transfer of factual information accounts for a low percentage of the training time in both the general mission and weapon employment training areas. The aircrew member is expected to know the necessary factual data for the aircraft systems and weapons prior to arrival at the unit and is expected to remain knowledgeable through self study of available regulations and manuals. The interviewees generally felt that this approach was acceptable and that most crew members could maintain acceptable systems knowledge with little effort. Upon initial arrival in the squadron, the crew member must learn the theater operating procedures (both peacetime and wartime) primarily through self-study, reviewing regulations and manuals with the help of squadron-developed study guides. Due to the security classification of many of the procedures, the aircrew member must study in a vault or classified work area, precluding removal of the material from the organization. Some one-on-one discussion with an instructor or a peer helps to clarify difficult concepts. Interviewees mentioned that film strip training aids were not very useful because they are not kept current.

The transfer of factual information related to electronic combat and general intelligence is frequently accomplished through group briefings and discussions. Assigned squadron or wing intelligence personnel present this information weekly or monthly. The formal presentations include visual aids, such as system drawings, photos and fact sheets.

3.2.2.2 Tactical Decision-Making

Many of the personnel interviewed had difficulty relating to the concept of decision-making training. However, after some discussion of the difference between a pilot who can fly the aircraft and a proficient combat pilot who can employ the aircraft, they generally accepted tactical decision-making as an acquired skill.

There was very strong agreement that the aircrew primarily receives tactical decision-making training through one-on-one discussions during the pre-flight briefings and post-flight debriefings. The second most frequently selected training medium was actual flight demonstration. The interviewees stated a number of times that tactical decision-making can only be learned through a thorough diagnosis and discussion of the situations faced during a mission. In most cases, interviewees felt that actual flight experience is essential due to severe limitations on the capability of simulators available at the unit level. Some notable exceptions to this concept were training degraded operations (emergency procedures), simple instrument flying and the electronic warfare officer position in the F-4G "Wild Weasel." One individual claimed that the video tape recorder (VTR) in the F-15 and F-16 is the single greatest training tool devised to date. Unfortunately, the VTR is limited in both the type of information it can capture and the length of time it can be operated. Several of the individuals interviewed said that the post-flight discussions often continued for several hours and that the VTR tape was used extensively to analyze events.

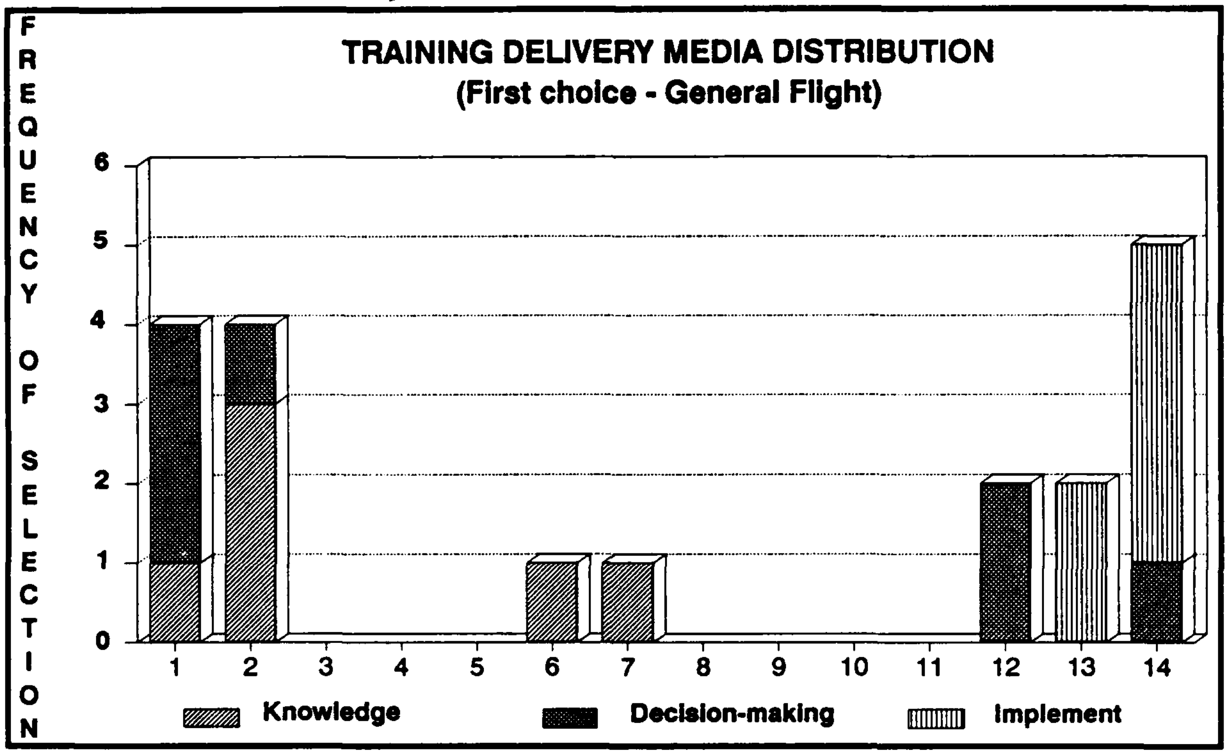

Figure 3.1-Primary training media distribution-General Flight

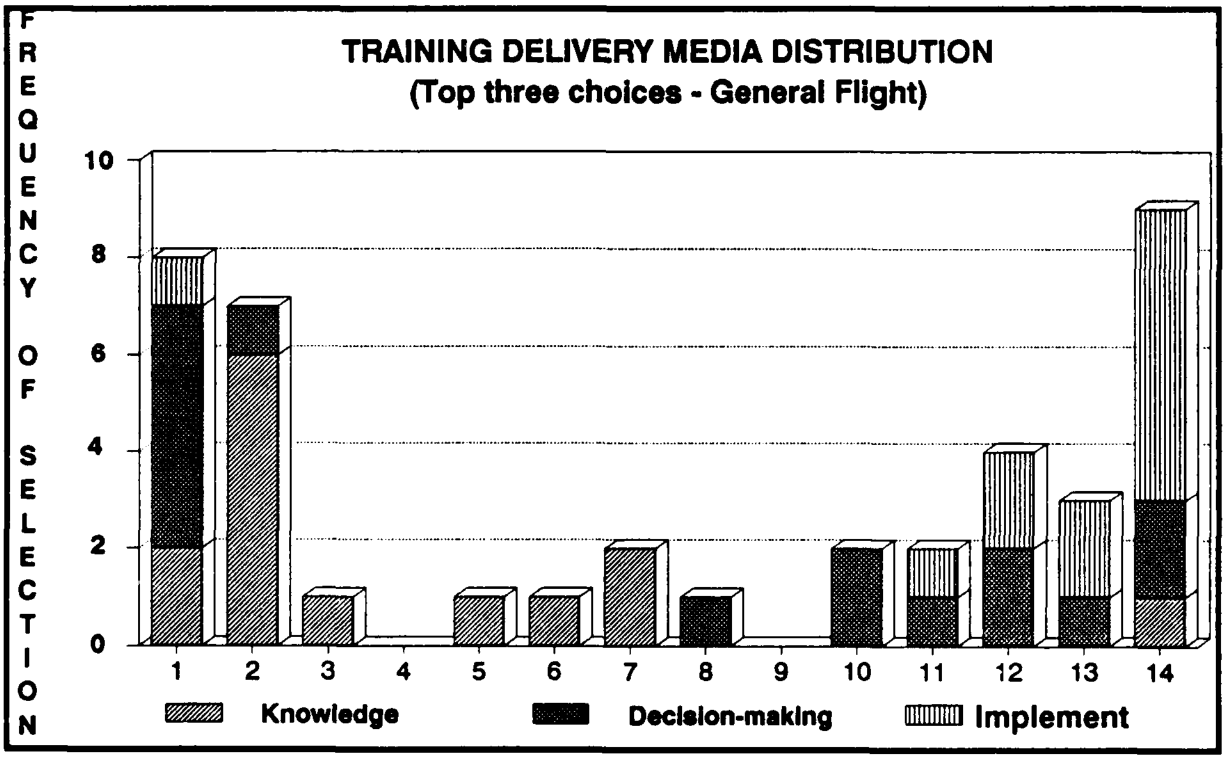

Figure 3.2-Cumulative training media distribution-General Flight

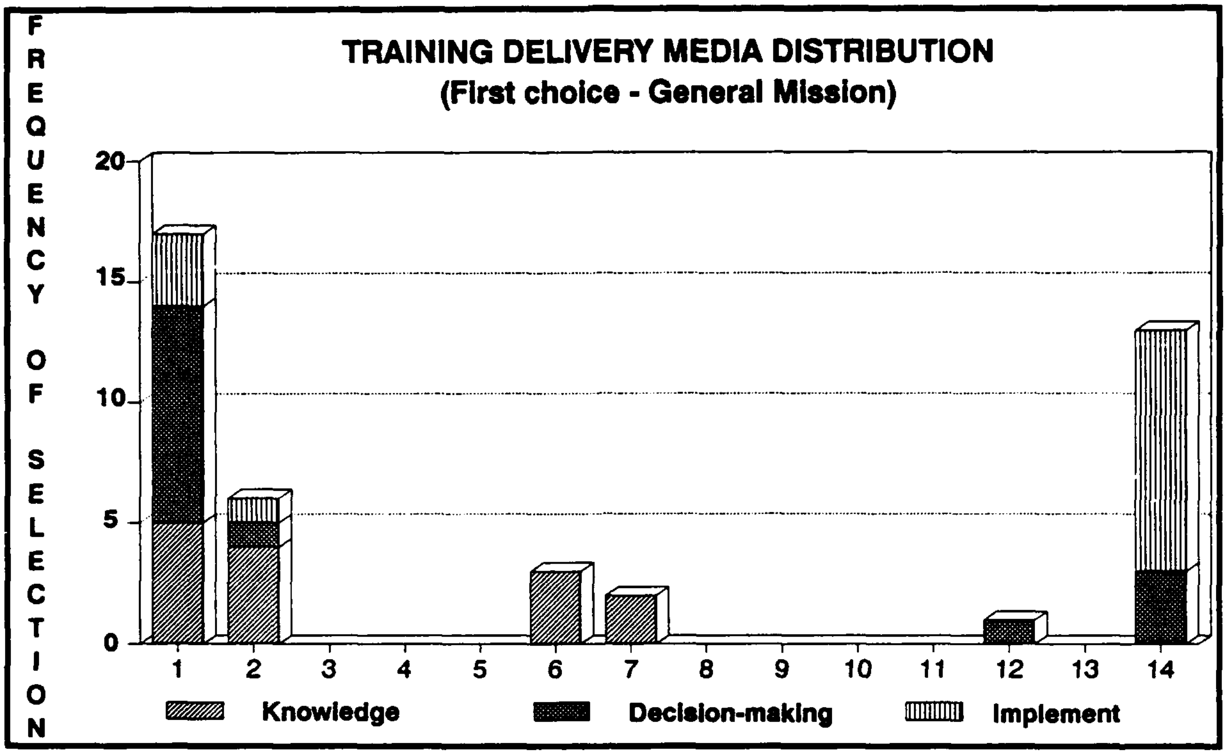

Figure 3.3-Primary training media distribution-General Mission

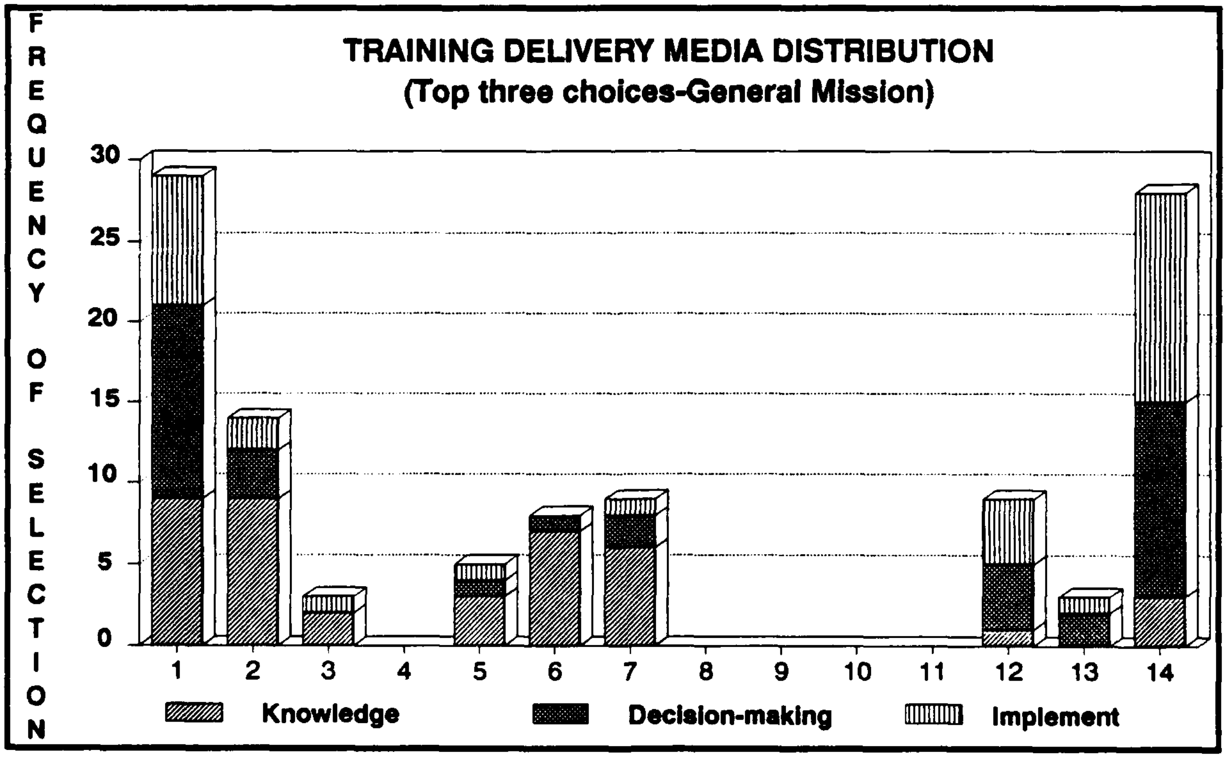

Figure 3.4-Cumulative training media distribution-General Mission

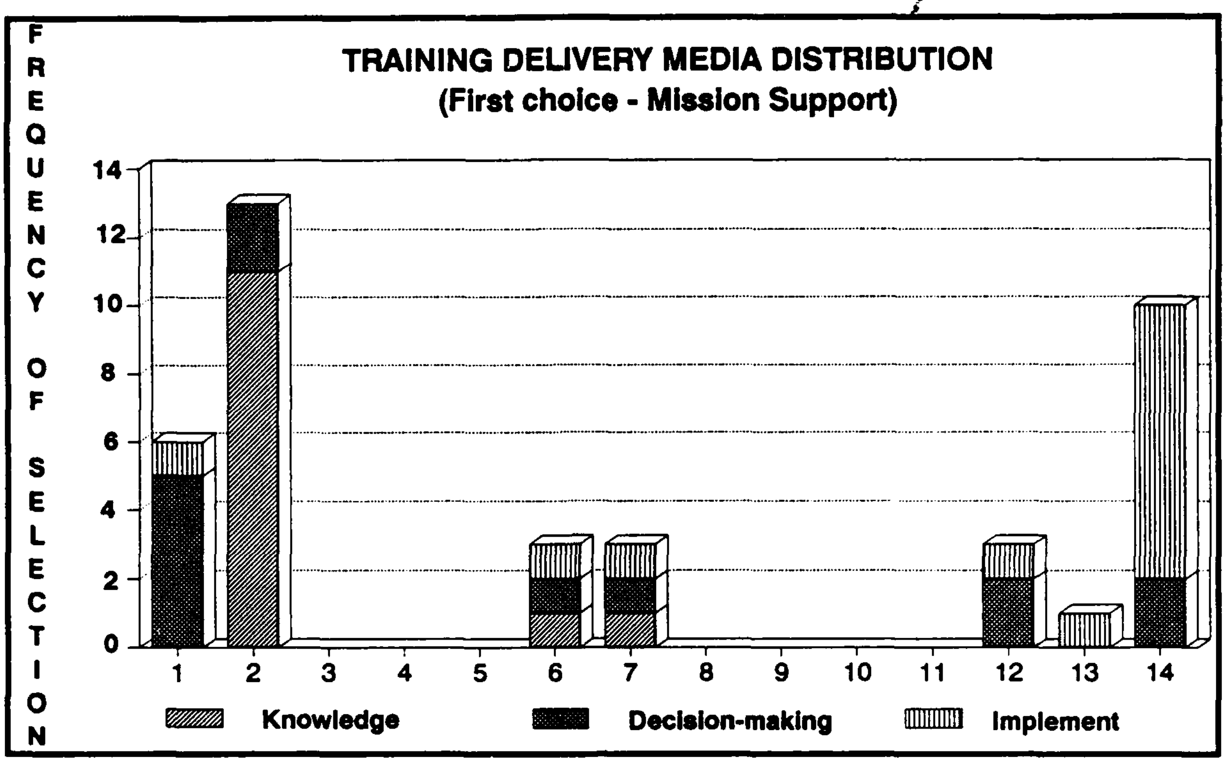

Figure 3.5-Primary training media distribution-Mission Support

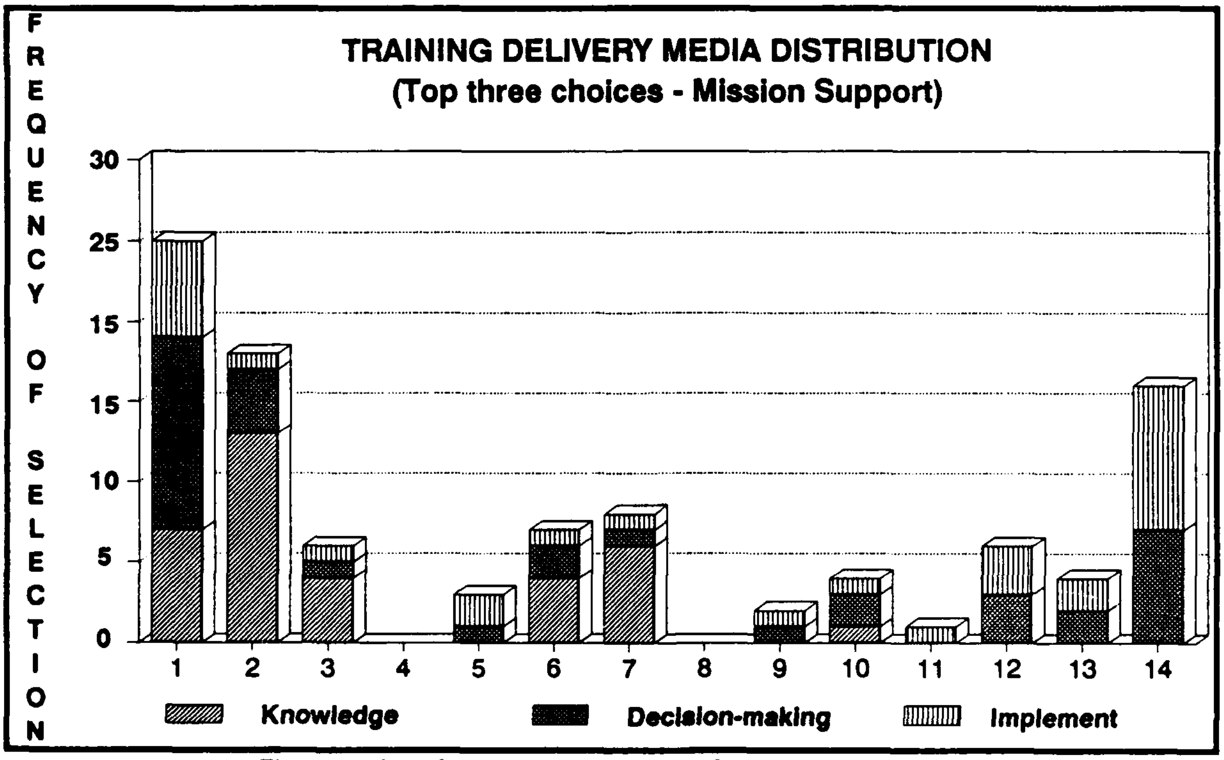

Figure 3.6-Cumulative training media distribution-Mission Support

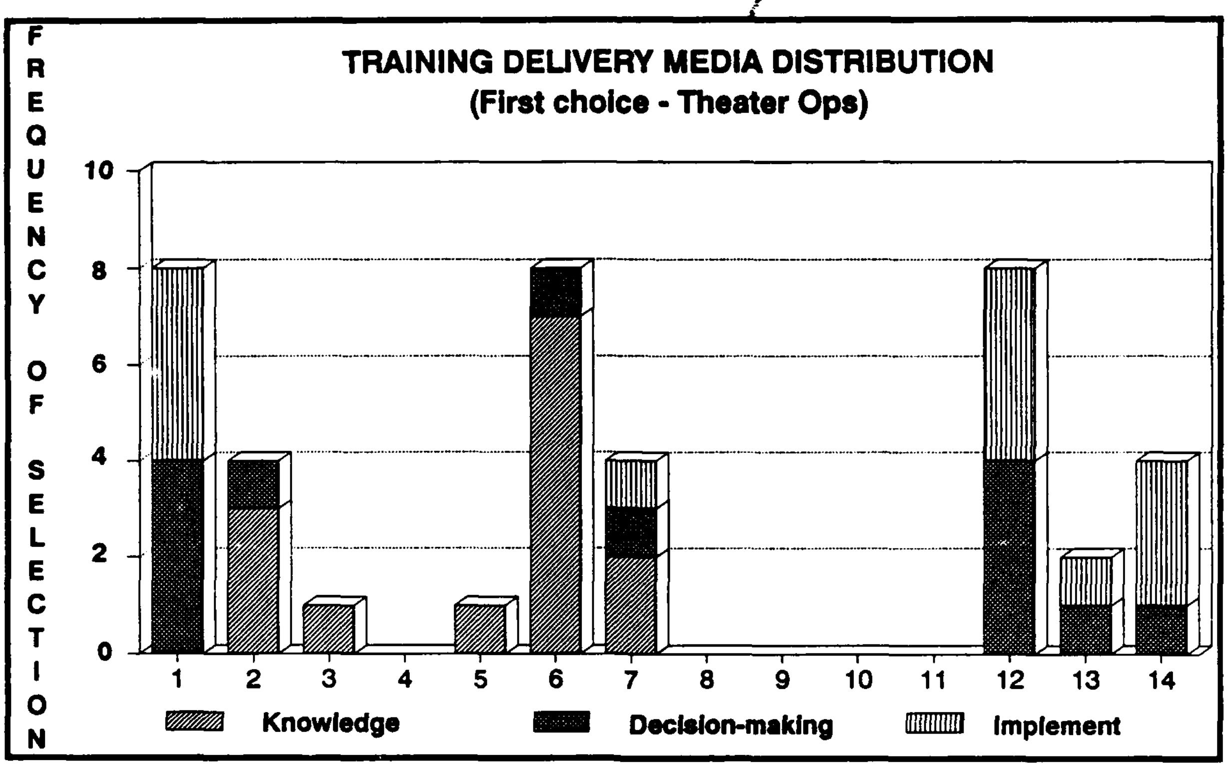

Figure 3.7-Primary training media distribution-Theater Operations

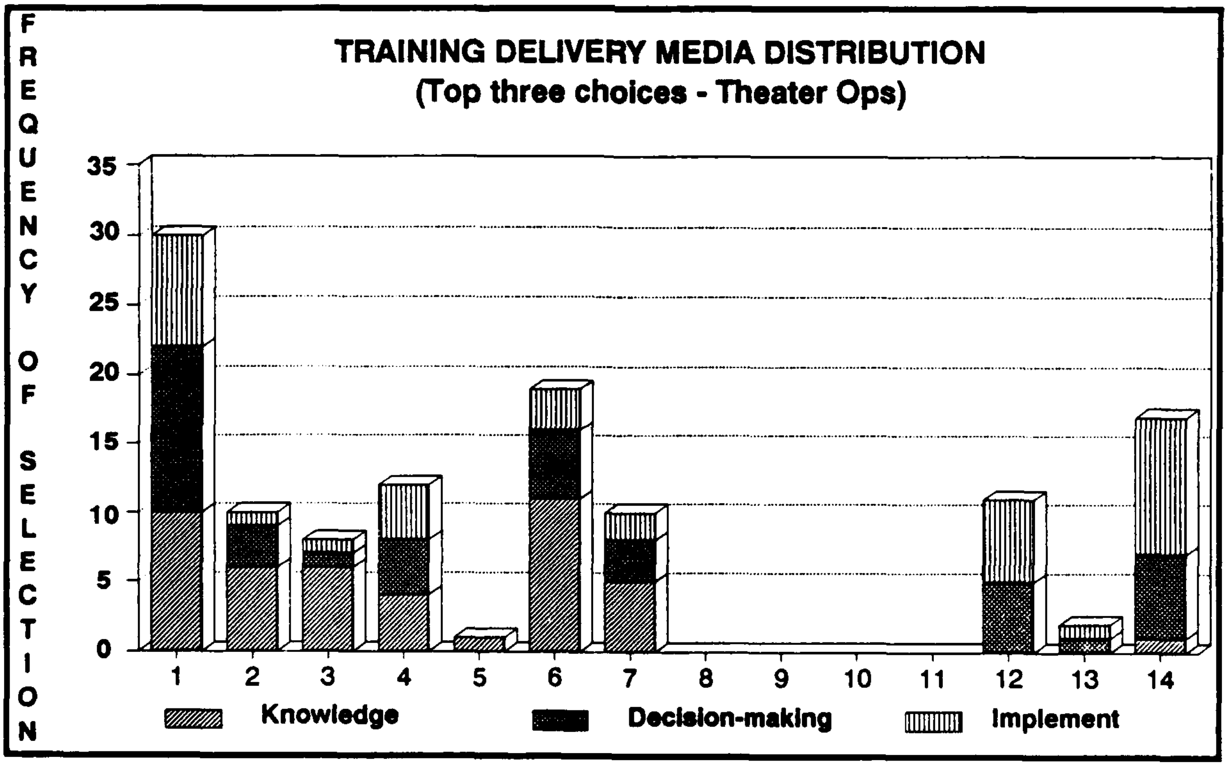

Figure 3.8-Cumulative training media distribution-Theater Operations

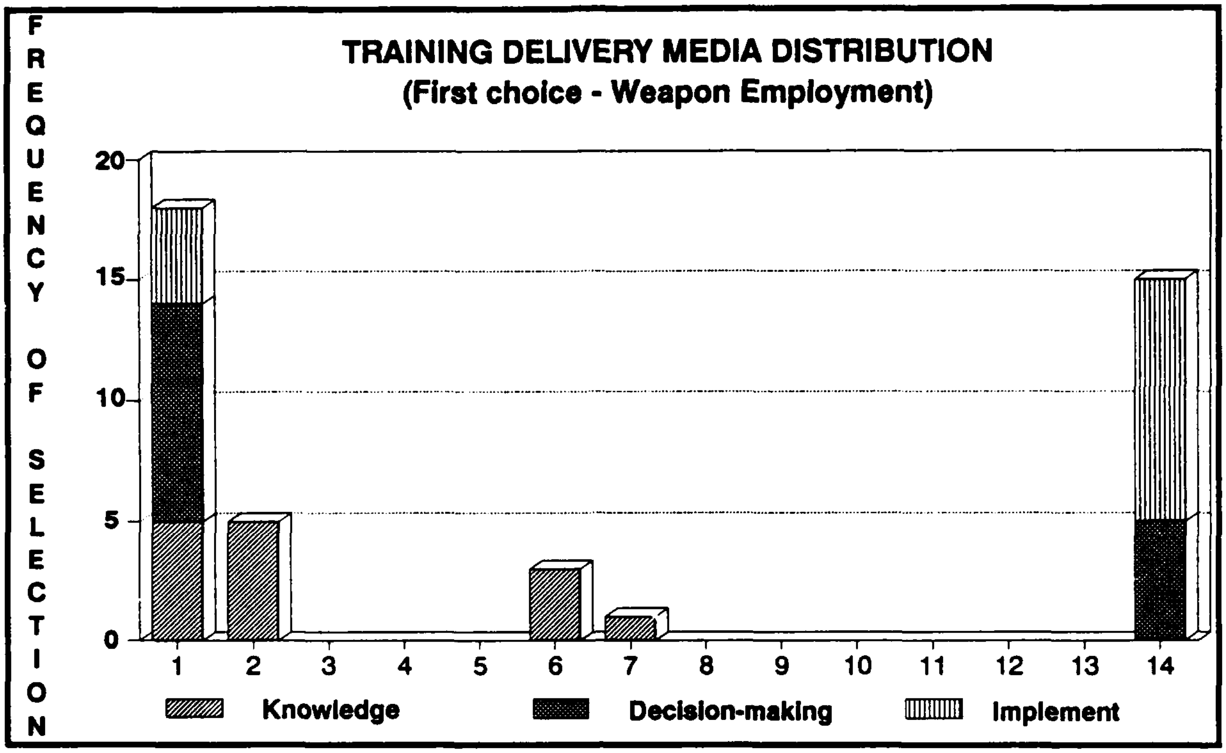

Figure 3.9-Primary training media distribution-Weapon Employment

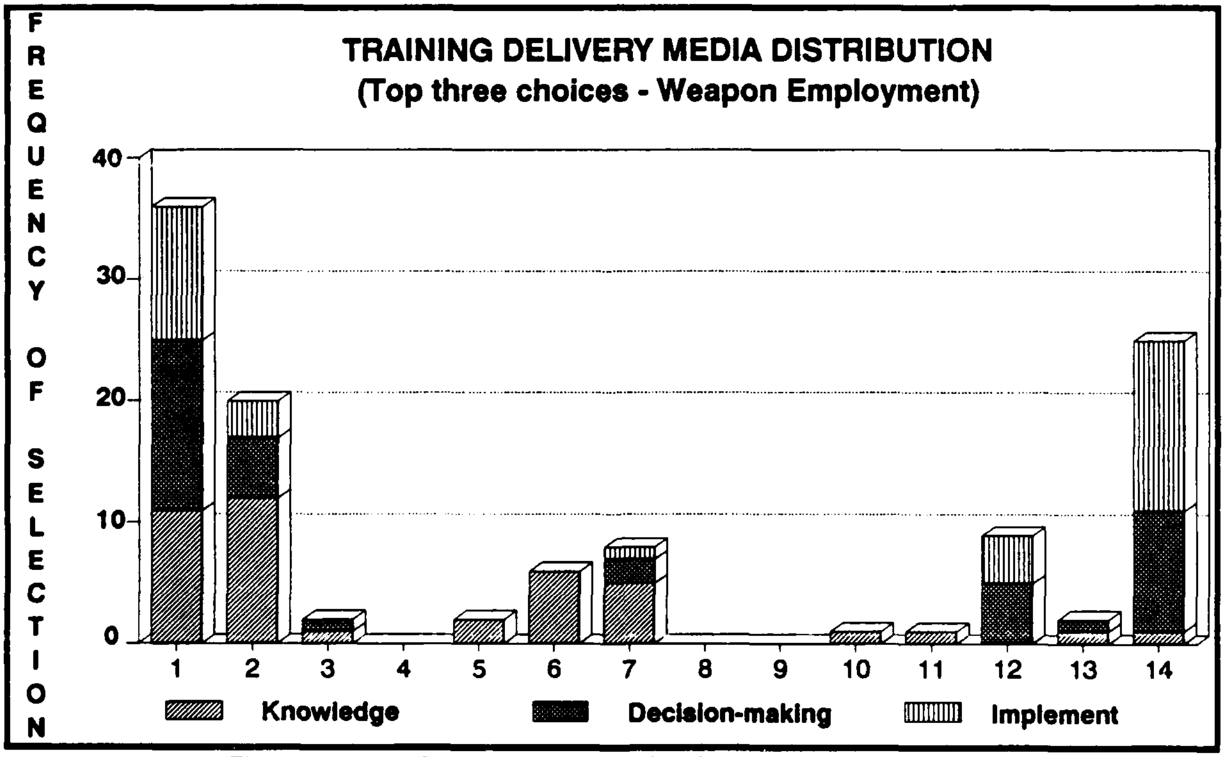

Figure 3.10-Cumulative training media distribution-Weapon Employment

3.2.2.2 Tactical Decision-Making

Many of the personnel interviewed had difficulty relating to the concept of decision-making training. However, after some discussion of the difference between a pilot who can fly the aircraft and a proficient combat pilot who can employ the aircraft, they generally accepted tactical decision-making as an acquired skill.

There was very strong agreement that the aircrew primarily receives tactical decision-making training through one on one discussions during the pre-flight briefings and post-flight debriefings. The second most frequently selected training medium was actual flight demonstration. The interviewees stated a number of times that tactical decision-making can only be learned through a thorough diagnosis and discussion of the situations faced during a mission. In most cases, interviewees felt that actual flight experience is essential due to severe limitations on the capability of simulators available at the unit level. Some notable exceptions to this concept were training degraded operations (emergency procedures), simple instrument flying and the electronic warfare officer position in the F-4G "Wild Weasel." One individual claimed that the video tape recorder (VTR) in the F-15 and F-16 is the single greatest training tool devised to date. Unfortunately, the VTR is limited in both the type of information it can capture and the length of time it can be operated. Several of the individuals interviewed said that the post-flight discussions often continued for several hours and that the VTR tape was used extensively to analyze events.

One-on-one discussions are not limited to the pre/post-flight briefings. Informal interactions between crew members occur virtually anywhere and at anytime. Whenever groups of pilots congregate, they can be seen "hand flying" and discussing (sometimes quite heatedly) recently experienced flight situations. The individuals interviewed generally agreed that this informal interaction of the older pilots recounting their experiences and influencing the judgment of the younger crew members is very valuable.

The interviewees indicated that group discussions are also a valuable tool for training decision-making skills. The weekly or monthly intelligence, weapons and tactics meetings serve as a forum for discussions on decision considerations in threat situations. One unit holds group seminars where the aircrews assembled with the express intent of analyzing and discussing potential tactical situations. They were convinced that these group seminars were very important since the nature and capability of the weapon systems they may face in future combat would be vastly different from those met in past combat (e.g., Viet Nam). They agreed that blindly using past decision making rules in today's environment could be deadly.

3.2.2.3 Implementation

The overwhelming selection for training necessary implementation skills was actual flight experience followed by one-on-one discussions. The consensus was that developing a feel for the system, refining control techniques, and honing reflex actions required practice in the flight environment. The selection of "one-on-one discussion" as a medium choice was not intended to be a standalone activity by those who chose it, but was instead mentioned as an adjunct to flight activity.

The interviewees infrequently selected simulators or part task trainers as a primary means of training implementation skills. They indicated that aircrews predominantly use simulators to practice basic instrument flying, emergency procedures, basic intercepts and electronic combat (particularly in the case of the F-4G "Wild Weasel"). The aircrews interviewed at the 7th Special Operations Squadron (SOS) in Germany, considered their mission to be conducive to the use of simulators for training of implementation skills since a high degree of visual and motion cuing is not required. Unfortunately, the simulator available to the crews is in New Mexico and is not in the MC-130E configuration. In most cases, the people interviewed indicated that except for actual flight, simulators are the only likely medium for training implementation, but require significant improvement. The two most frequently mentioned problems with the use of simulators for combat preparation training were: (1) lack of realistic visual and motion cuing, and (2) significant discrepancies between the configuration of the simulator and the actual aircraft.

3.2.3 Training Evaluation

The discussions concerning evaluation of proficiency in combat skills were directed to identify the methods used most often in identifying individual training needs and in selecting of personnel for upgrade. Each individual interviewed made selections from a list of evaluation methods and ranked them according to their frequency of use in making unit management decisions. Table 3.4 provides the codes for the training evaluation methods. Figures 3.11, 3.13, 3.15, 3.17, and 3.19 show the distribution of the primary method selected by interviewees for each training area. Figures 3.12, 3.14, 3.16, 3.18, and 3.20 show the distribution of the cumulative primary, secondary and tertiary evaluation method selected by the interviewees for each training area. Again, the values on the ordinate axis of the figures represent the cumulative number of times that the interviewees selected a given evaluation method. For example, Figure 3.13 shows that one person selected evaluation method number one (formal oral examinations) as the primary method for evaluating the transfer of factual information (knowledge) within the general mission training area.

1. Formal oral examinations (boards).
2. Informal oral examinations (discussions).
3. Written examinations.
4. Computer-aided evaluation.
5. Proficiency demonstration - simulated.
6. Proficiency demonstration - actual.

Table 3.4 - Training evaluation method codes

3.2.3.1 Knowledge

The most frequently selected method for evaluating an individual's comprehension of necessary factual information was written examinations. These examinations covered a wide variety of topics, ranging from quizzes administered during weekly weapons and tactics briefings to lengthy examinations accomplished as a part of the annual check-rides and periodic unit inspections. The interviewees felt that the value of the more formal written exams was low as a method of identifying specific training deficiencies since Master Question Files (MQFs) are developed and the majority of questions are taken from them. A problem with this procedure is that aircrews memorize a relatively small amount of information sometimes just prior to an examination. For this reason, the written exams could be viewed more as a training delivery technique than an evaluation method.

The interviewees also selected observation of actual flights and informal oral discussions as evaluation methods used within the unit. In both of these methods, the evaluator infers rather than explicitly measures an individual's grasp of necessary factual information. These two activities occur continuously within the unit and are used in combination for making training management decisions. Together they represent the evaluation method most frequently selected for the general mission and weapons employment training areas.

The use of formal oral exams was primarily limited to the theater operations training area. As a part of the initial MR upgrade process, the newly assigned aircrew member fully plans a realistic combat mission and defends his decisions before a board of senior officers. The certification/verification of personnel with a nuclear strike mission tasking uses a similar process.

3.2.3.2 Tactical Decision-making

The primary, and virtually the only method selected for the evaluation of decision-making skills was the observation of actual flight activities. With the exception of the VTR, the evaluator must rely on his memory and short notes for a record of flight situations. Observation of simulated flight activity was the second most frequently selected method which was particularly important for the evaluation of decision-making in degraded operational modes. In both of these cases, informal discussions following the actual or simulated activity reinforce the evaluator's observations.

3.2.3.3 Implementation

The interviewees selected observation of actual flight activity as the evaluation method most frequently used to assess the aircrew's ability to implement decisions. The observation of the simulated flight activity evaluation method was sparingly selected due to the significant restrictions on available simulators. Again, informal discussions supplement direct observation.

3.2.4 Training Challenges

Each individual interviewed was asked to describe the most significant challenges facing them in accomplishing their goals of developing and maintaining proficient combat pilots. The most frequently mentioned problems dealt with the availability of training airspace. The interviewees indicated that the number of restrictions on the use of airspace and the lack of training ranges is a serious problem now and that it appears to be getting worse. The interviewees felt that restrictions placed upon low altitude and night flying make training in these environments nearly impossible, especially in USAFE. The lack of availability of weapons delivery, electronic combat and Air Combat Maneuvering Instrumented (ACMI) ranges and severe limitations on approaches to the ranges and maneuvering within them is also causing significant training problems. Lengthy and frequent relocations to other geographical areas is necessary to address the problem, thereby restricting the frequency of training activities.

Several individuals also mentioned that a lack of an effective training management method is a problem. The current event oriented training management method makes it difficult to evaluate training needs and schedule individual training activities. Some interviewees felt that the management methods stress sortie generation more than quality of training.

Several of the interviewees highlighted variable levels of expertise in unit instructors. Unit commanders select instructors based upon the aircrew member's superior flying skills rather than on the ability to diagnose training deficiencies and transfer skills. In addition, there is little formal training to improve the instructor's ability to accomplish training responsibilities.

Although efforts have been taken to reduce the number of additional duties within the units, the time spent on activities not related to combat preparation is still a problem particularly for the more experienced personnel who are assigned other responsibilities within the squadron and at the wing level, e.g., flying safety and standardization. The introduction of a significant number of single seat aircraft into the Air Force inventory, replacing older two seat F-4s, effectively reduced the number of aircrew members assigned to the units by half. Although the number of available personnel was reduced, the number of additional duties remained unchanged.

The interviewees felt that the effectiveness of simulators is limited due to a lack of realistic visual and motion cuing, as well as a failure to maintain the simulators in the same configuration as the aircraft. Air combat is a dynamic, three-dimensional activity that relies heavily upon visual stimuli especially for close-in air-to-air combat, low altitude maneuvering, and weapons delivery. Interviewees generally agreed that simulators without visual and motion cuing are not effective for continuation training of experienced aircrews. Of equal or of greater concern, was the numerous discrepancies between the simulators and the actual aircraft. The F-15 and F-16 aircraft are frequently upgraded with new or modified equipment and computer software modifications which are not introduced into the simulators with equal priority. Consequently, the aircrew must learn how to fly the simulator each time they get into it, and the practice they receive in the simulator is not transferable to the aircraft. Some of those interviewed indicated that current simulators provided negative training in some instances.

3.3 Training Research and Development

An examination of current and completed research and development (R&D) relatable to aircrew combat preparation training was performed. This section contains an overview of literature on completed training-related R&D and a survey of specific ongoing R&D efforts.

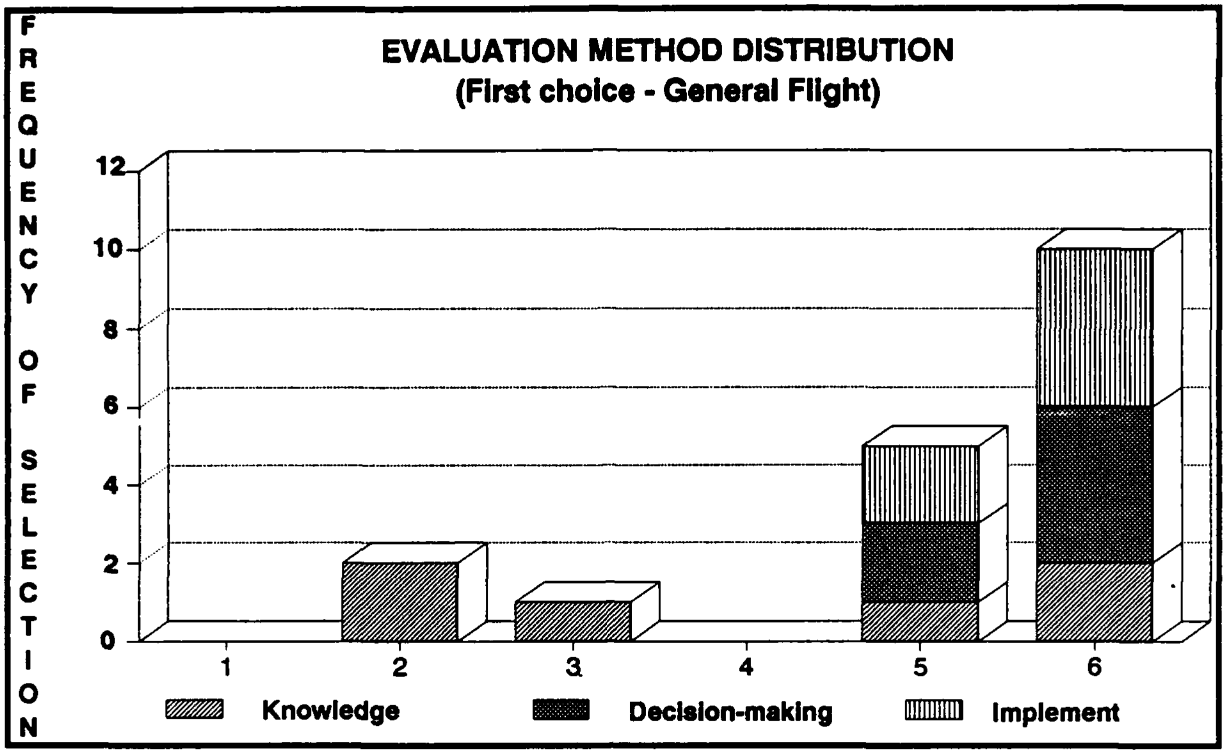

Figure 3.11-Primary evaluation method distribution-General Flight

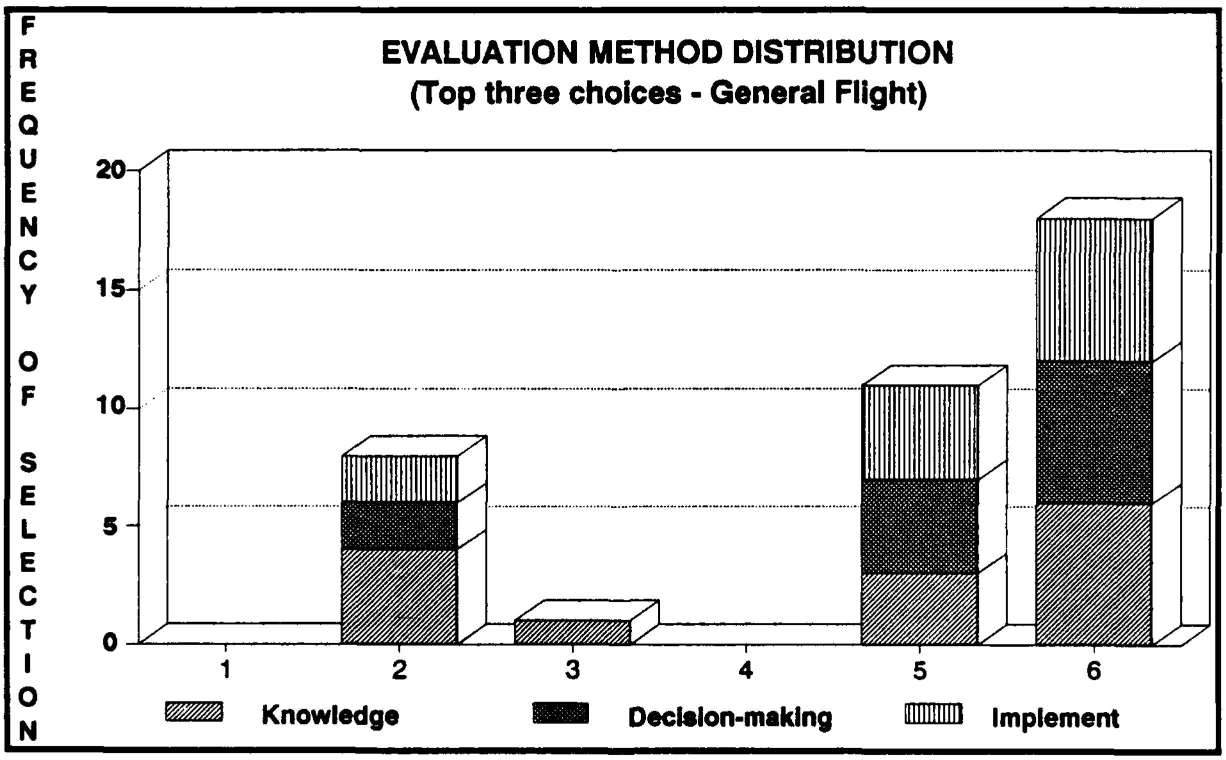

Figure 3.12-Cumulative evaluation method distribution-General Flight

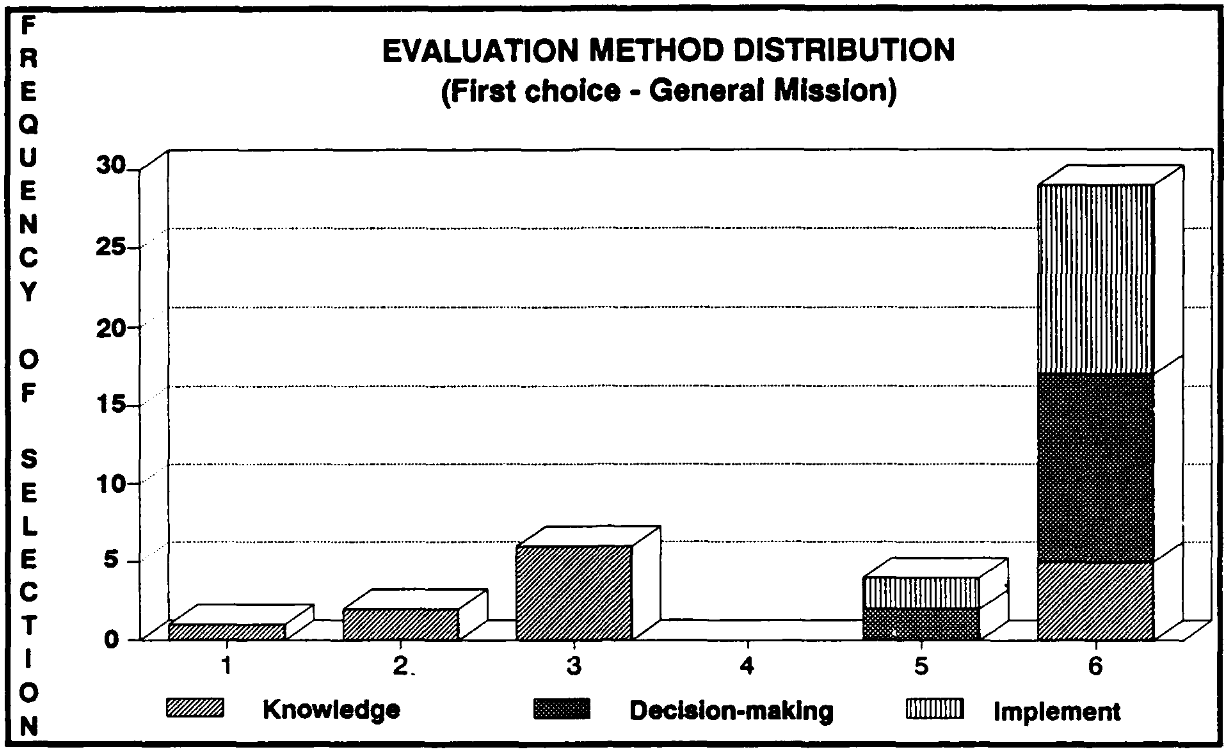

Figure 3.13-Primary evaluation method distribution-General Mission

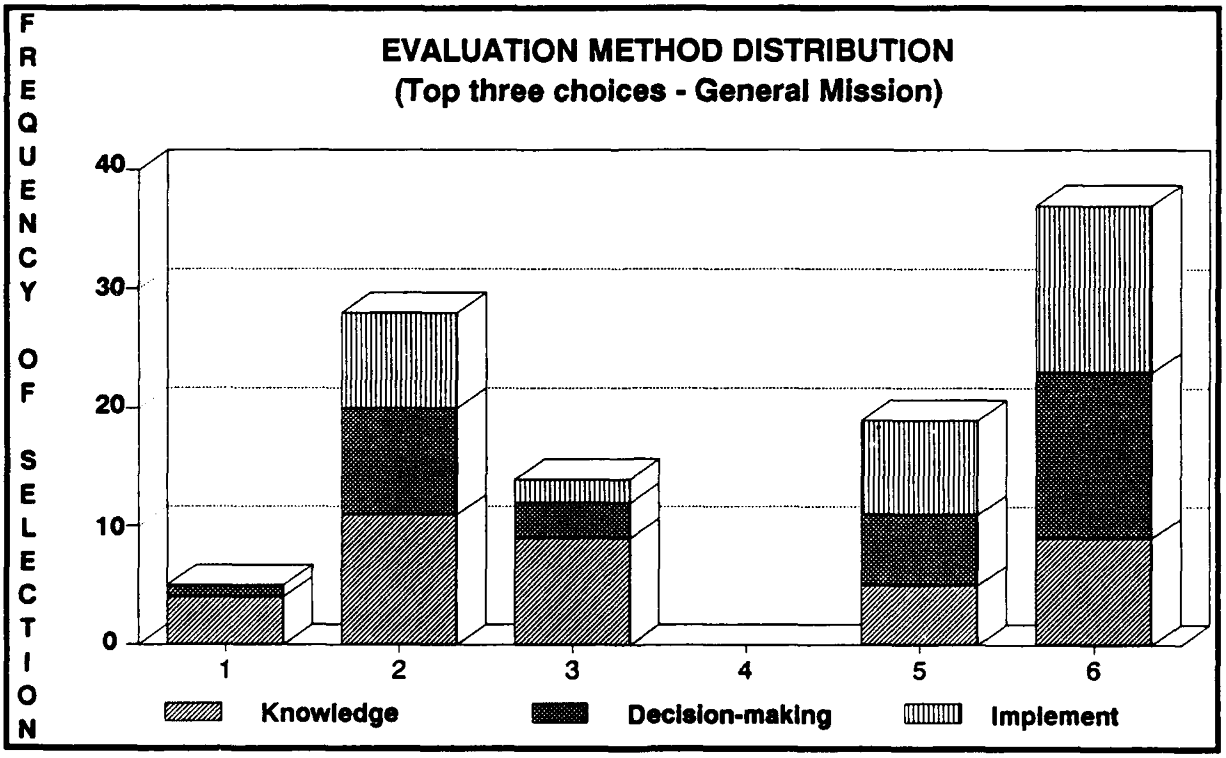

Figure 3.14-Cumulative evaluation method distribution-General Mission

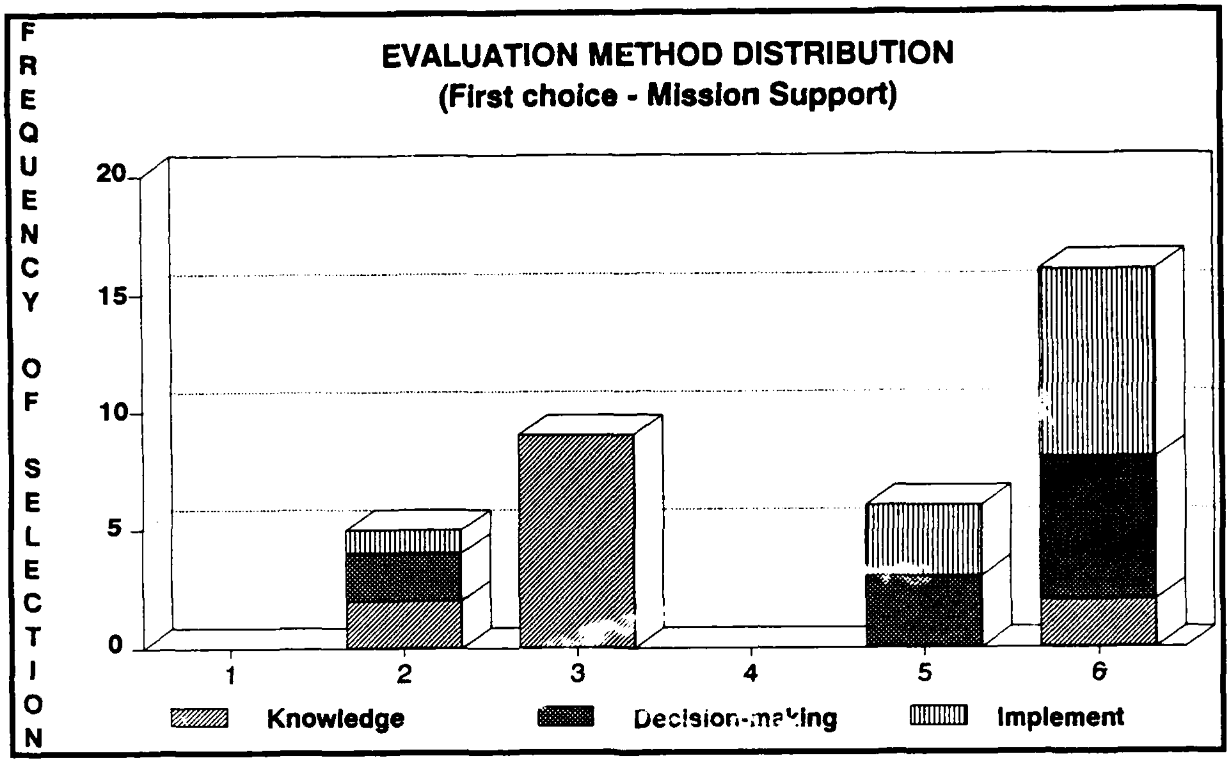

Figure 3.15-Primary evaluation method distribution-Mission Support

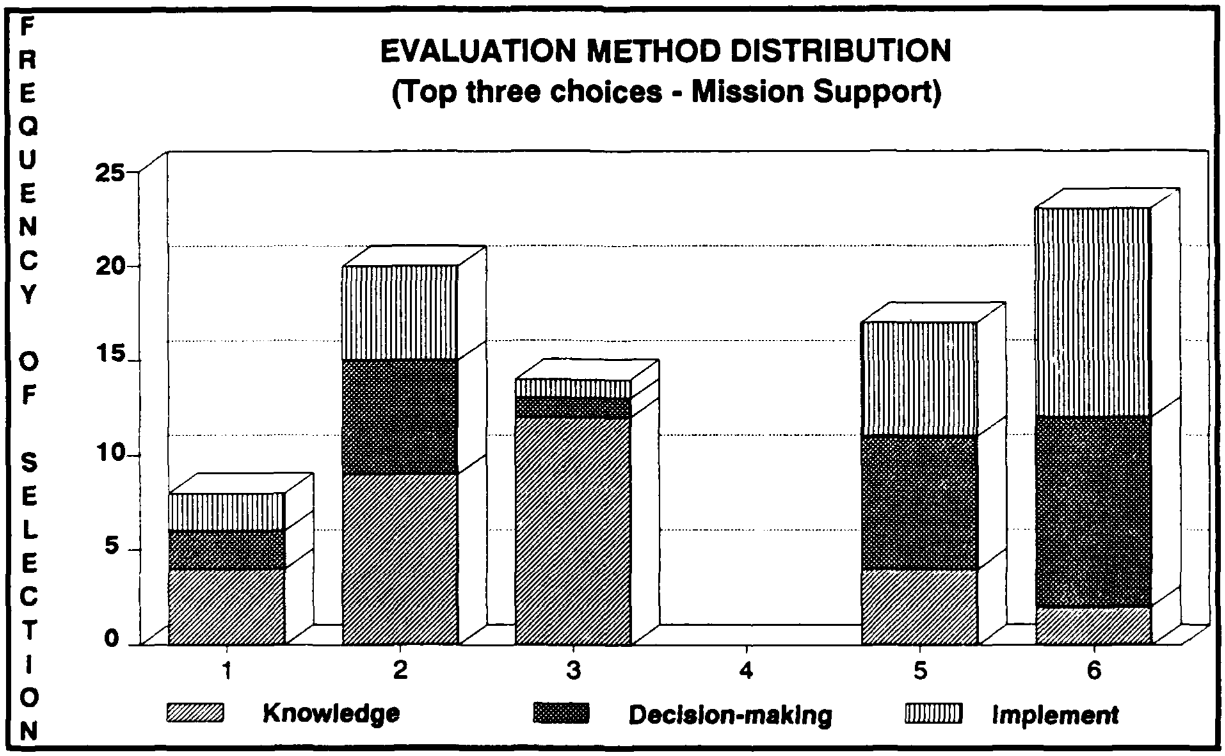

Figure 3.16-Cumulative evaluation method distribution-Mission Support

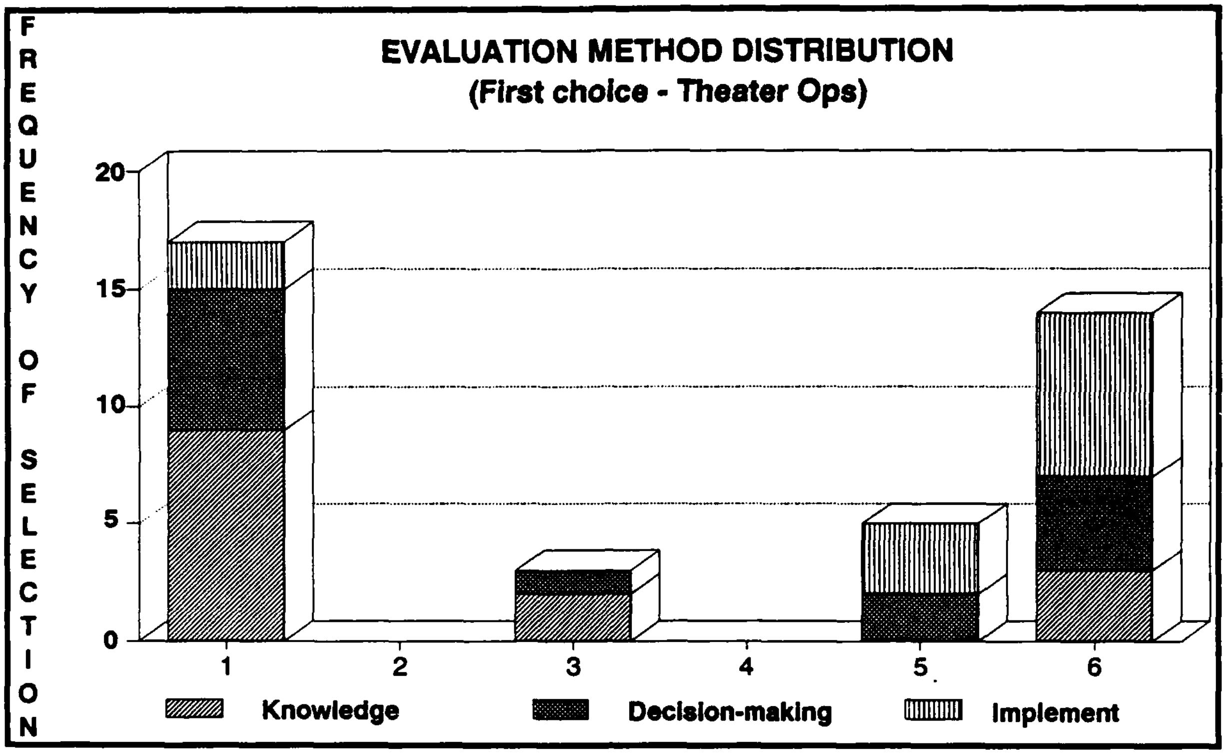

Figure 3.17-Primary evaluation method distribution-Theater Operations

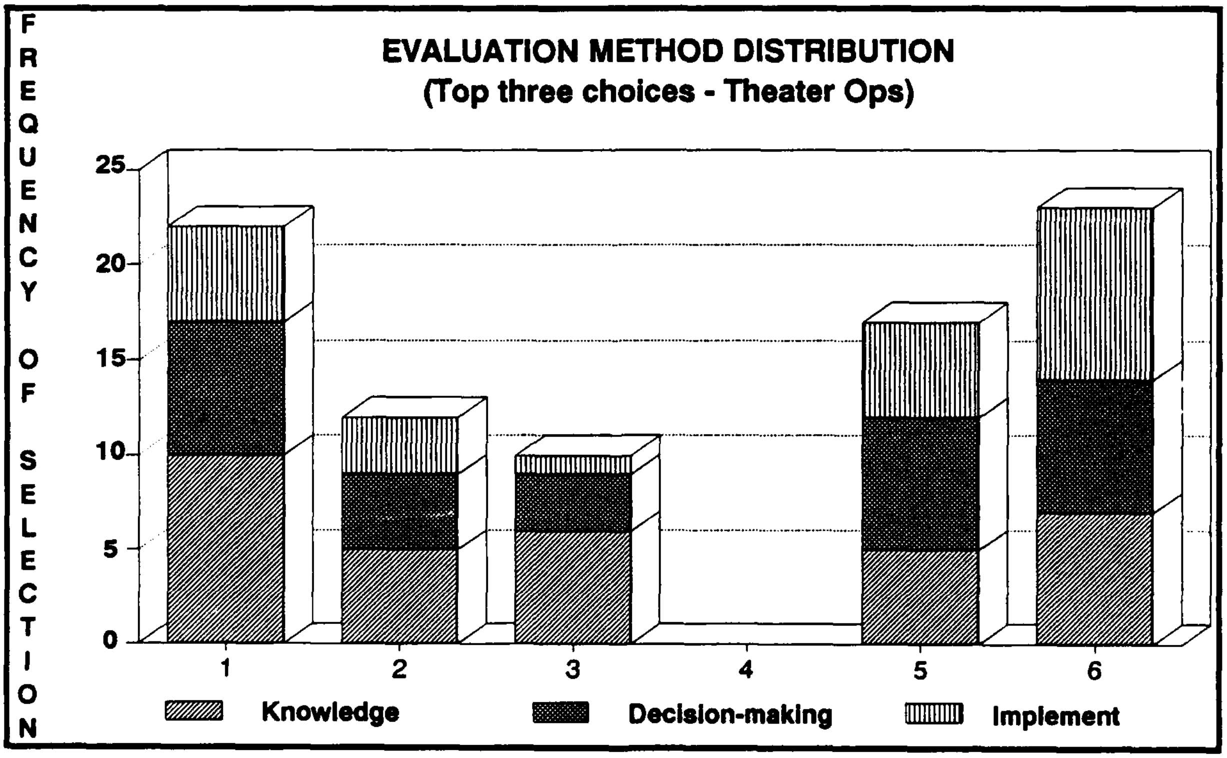

Figure 3.18-Cumulative evaluation method distribution-Theater Operations

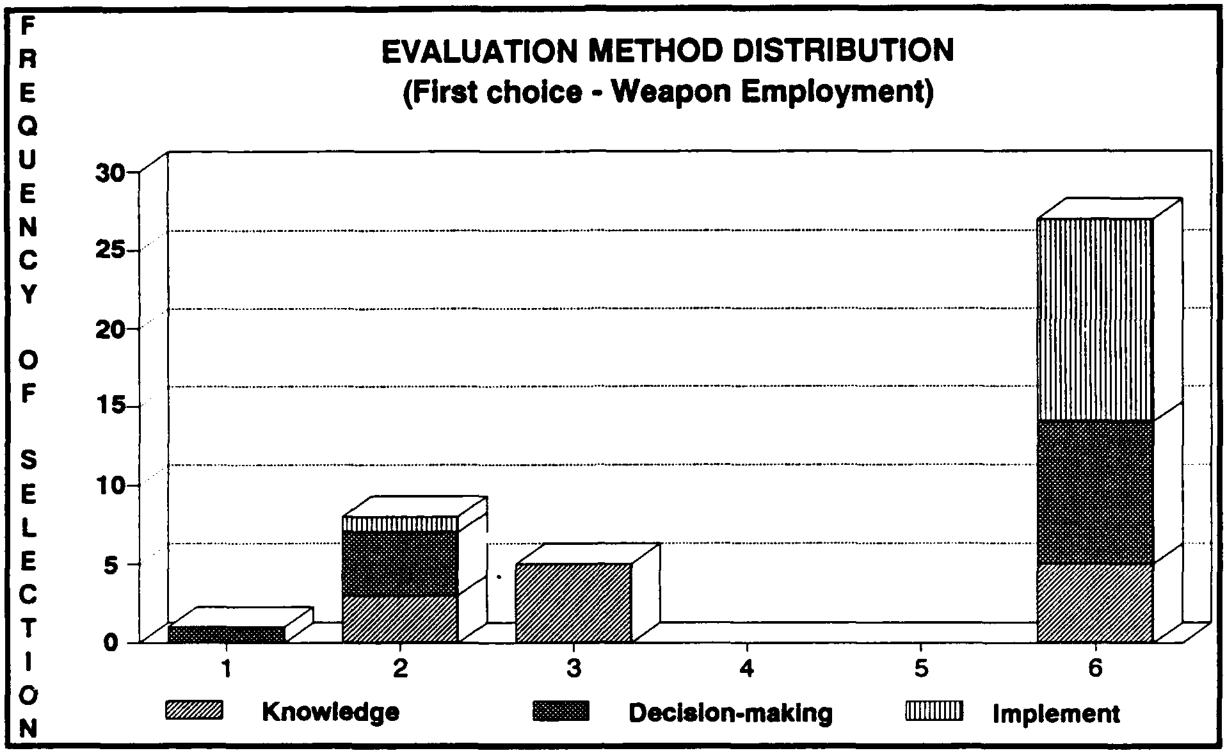

Figure 3.19-Primary evaluation method distribution-Weapon Employment

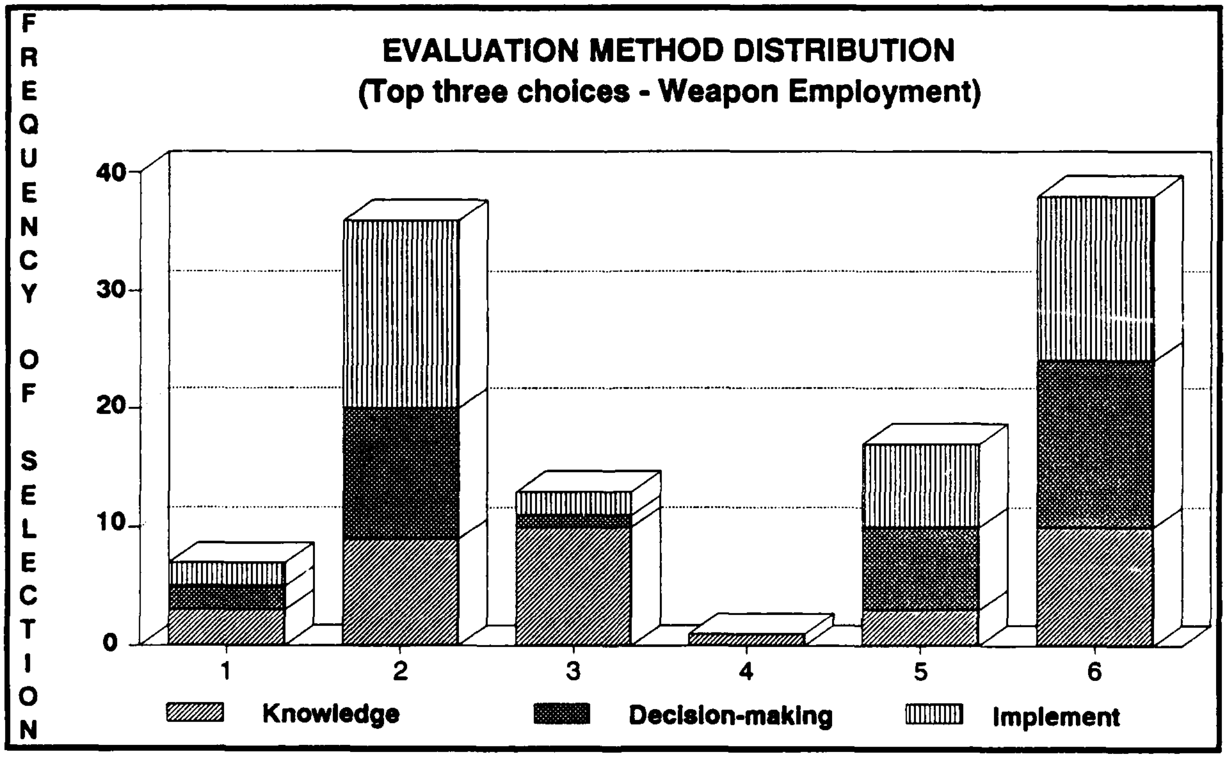

Figure 3.20-Cumulative evaluation method distribution-Weapon Employment

3.3.1 Completed Research and Development

Existing literature was reviewed to provide an overview of training related R&D. This section presents R&D activities on the demands of the combat environment, decision-making, the impact of stress on performance, and advanced training systems.

3.3.1.1 Demands of the Combat Environment

Although no research was found which specifically analyzed the nature of the current combat environment and its potential effects on the human, an examination of this environment was an inherent part of several research projects (Courtice, 1988; Craft & Koehler, 1988; Hartman, 1988; Kantor & Skinner, 1984; Spettell & Liebert, 1986; Stone, et al., 1985). Generally, they view the combat environment as becoming more complex and time-critical as equipment and the threat become more technologically advanced. Today's potential combat environment will place extremely high demands on the aircrew's higher order cognitive processes. The integration of complex procedures is critical to successful air combat. For example, tests using the Advanced Medium Range Air-to-Air Missile (AMRAAM) in 1981 (Courtice, 1988) illuminated the necessity of task integration. In the test, combat pilots previously qualified in individual courses of instruction had trouble operating multiple systems and accomplishing complex procedures simultaneously. Killion's research (1986) on the effectiveness of combat range training also addressed task integration. His data show that combat performance, requiring integration of combat tasks, deteriorates significantly in as little as four to six months after range training. This finding suggests that routine training at unit level does not preserve skills developed or improved in special training exercises such as Red Flag.

The process of evaluating and analyzing effective performance frequently uses task analysis methodology. Task analysis involves the breakdown of a particular job into discrete tasks. The Air Force's Skills Maintenance and Reacquisition Training research program (Project SMART) applied this technique. The objective of Project SMART was to "...identify and define critical combat skills of mission-ready aircrews and to develop procedures for measuring these skills." The project included analysis of the pop-up weapon delivery task and the low altitude tactical formation (LATF) task. A task analysis was successfully performed on the pop-up weapon delivery task, which is a short duration maneuver (forty seconds) and lends itself well to the breakdown of discrete subtask segments (Lyon, et al., 1980). The analysts assessed aircrew skill in each of these segments, compared it to overall performance of the maneuver and identified elements felt to be most critical to successful weapon delivery. The study also showed that "...pilot self-assessment can be a useful source of data in identifying critical aircrew skills." The LATF task takes more time (over one hour) and varies in its requirements (DeMaio & Eddowes, 1980). These factors led to the conclusion that the LATF task was not easily standardized or divisible into segments. Instead, the study focused on various skill/proficiency elements and their contribution to overall mission success. Pilots at Davis-Monthan AFB identified possible mission-critical skills, and the researchers compared proficiency of these skills to overall mission performance during special LATF missions and at Red Flag training exercises. Variables contributing significantly to successful LATF were identified through regression analysis. The researchers observed that the increased workload associated with the higher threat environment at the Red Flag exercises, as compared to routine training missions, statistically increased the criticality of visual skills. Task analysis has also been applied to the undergraduate pilot training environment to identify behavioral objectives in mastering flying tasks (Kantor, 1984).

The combat environment facing future aircrews will place extremely high demands on their higher order cognitive processes. This environment will become more demanding as equipment and the threat become more technologically advanced. The cognitive processes involved in many combat activities are very intricate, making them difficult to standardize or divide into discrete, ordered steps. Current task-oriented methods of training development may not effectively prepare aircrews for combat in the future. An emphasis on underlying skill identification and development may be required.

3.3.1.2 Decision-Making

Many theories on decision-making strategy exist. These include probability theory, gambling theory, the minimax rule, Bayesian strategy and many others (Coyle, 1972). When applied to decision-making, all attempt to provide a method for selecting an optimal action, given several alternatives with several outcomes. Probability theory predicts the outcome of a random event, such as the toss of a coin. Gambling theory uses probabilities to compare chances to win/lose with the amount potentially won or lost. Courtice (1988) suggests that gambling theory may be applied to combat decision-making in a simpler form. Instead of performing time-consuming mathematical calculations of probability statistics, the combat aircrew may attempt to deal with uncertainty by selectively eliminating alternative actions until the optimal one remains. Bayesian strategy, developed by Thomas

Bayes, uses probabilities and expected payoffs to select the best actions. The minimax decision rule, developed by Abraham Wald, uses a pessimistic perspective and attempts to maximize the minimum achievable payoff.

Existing decision-making theories may be difficult to apply to combat decision-making due to the much higher risk, uncertainty, timing and criticality of the decisions compared to normal decision scenarios. Pilot decision-making has been a subject of research in connection with commercial airline accidents. A study conducted by the Airline Pilots Association (Stone et al., 1985) observed that the decision-making process during flight is poorly understood. The research found that the majority of incidents occurred in situations involving time criticality or pressure -- situations that place extra strain on cognitive decision-making processes. Research conducted at the Institute for System Studies in Moscow (Larichev & Moshkovich, 1988) investigated the effect of increasing complexity on decision strategies. The experiments support the conclusion that humans change their strategy as the complexity of the situation increases. As the cognitive load increased, the researchers observed that some subjects attempted to reduce the load on their information processing system by eliminating some alternative actions before beginning the evaluation process. Supporting this observation, experiments in 1960 (Taylor, 1984) demonstrated that in an uncertain environment, humans tend to ignore the uncertainty to reduce anxiety.

Process tracing is a method developed for investigating decision-making processes in complex situations. This method involves asking individuals to speak aloud as they are processing information and making choices. In situations involving information overload or time pressures, research in 1974 using process tracing (Taylor, 1984) found that some humans attempt to simplify the decision by quickly counting the alternatives' superior attributes and comparing them two at a time. Researchers have studied the decision-making process to determine if it can be separated into distinct stages. Taylor (1984) presents several theories on these stages, including the classical breakout of (1) defining the problem, (2) gathering information, (3) exploring alternatives, (4) evaluating alternatives, and (5) choosing the optimal alternative. Task analysis, embodied in the USAF's Instructional Systems Development (ISD) manual, is frequently applied to procedural and independent sequential actions, but researchers have observed that it is difficult to apply to complex interrelated processes, such as those associated with decision making (Craft & Koehler, 1988). Research conducted in 1972 (Taylor, 1984) supported the view that decision-making does not follow a sequential path, but that the five activities are dispersed throughout the decision process. Making critical decisions under uncertainty has been studied in a medical context (Kuipers et al., 1988). Researchers studied expert physicians solving a problem involving substantial uncertainty and risk. The objective of the study was to determine the reasoning strategies used in making these difficult decisions. The research found that the doctors broke the decision down into a series of incremental decisions and used the small amount of information available to make these individual decisions. The physicians ultimately made their final decision on the basis of the smaller decisions. When using this process, the decision-maker does not comprehensively assemble all facts prior to any decision-making activity but instead gathers information continuously while making incremental decisions.

An important aspect of aircrew decision-making is situation awareness (SA). Situation awareness is knowing what is going on within a volume of space which can affect the pilot and the mission, knowing where the threats are and what they are doing, and knowing what the flight knows and its options for offense and defense. It provides a basis for making decisions that maximizes the likelihood of mission success and the aircrew's survivability. The increasing mental workload demanded of aircrews compounds the complexity of the decision process and increases the need to identify better ways to enhance SA. Two research efforts are cited here as examples of research into SA, its importance in the combat arena and how it can be improved through training. A macro approach to SA can be observed in the 1988 research of Craft and Koehler. The researchers focused on the attention and perception processes involved in SA in order to understand the associated cognitive processes better. This understanding will enable the development of more effective SA training methods. Situation Awareness Training, a research project headed by Dr. Bryce Hartman at the United States Air Force School of Aerospace Medicine (USAFSAM) analyzed methods to improve aircrew performance in target detection, recognition and identification through improving response to visual cues. The experiment, using 10 ROTC students as subjects, involved the recognition of a short duration (250 to 17 milliseconds) stimulus. A comparison of pre-training and post-training test scores showed an improvement in performance after five days of three or more hours of training per day. Dr. Hartman's work in improving visual perception is an excellent example of a method which could be used in developing attention/perception skills associated with SA. This type of training could contribute to enhanced aircrew performance by improving judgment, decision making, and stress and risk management. Improvement in these performance factors leads to a better ability to effectively handle critical situations.

Easing pilot workload under combat conditions is the thrust of a R&D project called the Pilot's Associate.

The effort is developing an artificially intelligent decision aid to guide aircrew actions during different stages of the mission. The program, being developed by Lockheed, will use data provided by on-board sensors to determine threats and recommend action.

A review of decision-making R&D was conducted to increase the understanding of decision-making demands on combat aircrews, the decision-making process, and how decision-making can be enhanced. It was found that combat conditions differ greatly from normal decision-making environments in such factors as time pressure, personal safety concerns, and stress level. For this reason, existing decision-making theories may have limited applicability to the air combat environment. Due to the non-sequential and sometimes unpredictable nature of this environment, current training development techniques, which rely heavily on task analysis, are difficult to apply to the decision-making task. Recent R&D projects were identified which increase the understanding of SA, an integral part of the decision-making process. This research may provide the means for enhanced combat decision-making training in the future. In addition, ongoing R&D efforts are attempting to reduce the decision-making workload by providing the aircrew with artificially intelligent decision aids.

3.3.1.3 Impact of Stress on Performance

Stress has a detrimental effect on problem solving behavior (Spettell & Liebert, 1986; Taylor, 1984). Taylor cites 1967 research showing that there is an optimal level of stress that yields the most efficient use of information processing capability. At very high stress levels, cognitive processes begin to deteriorate as the demands of the problem begin to exceed cognitive processing capacity. Researchers have developed methods to indicate and measure stress response. These methods include monitoring hormonal excretion through urinalysis, analyzing vocal microtremors and measuring electrical activity of the brain (Kantor & Skinner, 1984). Researchers at the State University of New York at Stony Brook (Spettell & Liebert, 1986) have "studied cognitive and affective factors that potentially threaten operators' performance and show how psychological training techniques in problem solving and stress [management] may help to neutralize these threats." This study conclud ed that the role of decision-making is crucial in the operation of man-machine systems, especially in those situations involving malfunctions or emergencies. Spettell and Liebert stated that problem solving is usually done by formulating discrete hypotheses based on all available information and sequentially testing them. However, humans often overlook non-obvious possibilities in this situation assessment. The researchers indicated that time pressure and heavy workload also adversely affect problem solving and information processing behavior in situations involving risk. The research found that even when students are taught a high-efficiency problem solving strategy, they tend to abandon it in demanding situations.

Some R&D activities are exploring methods to control the undesirable effects of stress on performance. These methods include training under similarly stressful conditions which might be encountered in actual operating situations and employing coping strategies for dealing with stress-induced panic. The stress under which an aircrew member must function during combat may be similar to that which an athlete experiences during competition. The athlete is responsible for peak performance in high stress situations and must learn to function under these demanding conditions. The field of sports psychology is being accepted as a legitimate branch of psychology, as evidenced by the team of sports psychologists included in the 1988 Summer Olympics staff in Korea. Sports psychology offers several methods of preparing for and dealing with high anxiety situations. Psychological preparation techniques used by athletes include visualization, goal-setting, self-hypnosis, positive thinking, meditation, and biofeedback. This mental conditioning enhances concentration or relaxation and reduces nervousness and distraction. Visualization involves using visual imagery to "see" a successful performance. Combined with goal-setting and positive thinking, this mental conditioning helps to remove doubts about perceived shortcomings or faults. The athlete is encouraged to think only of winning or setting a record, and not to dwell on the possibility of losing. Regular sessions of self-hypnosis, meditation, and biofeedback prior to competition lessen the possibility that anxiety will cause poor performance. The latter techniques help the athlete gain control over involuntary bodily reactions to stress, for example, erratic breathing and heartbeat. The athlete who is able to confront and overcome panic feels more in control of the situation and better prepared to complete. Such strategies can improve performance in demanding situations (Orlich, 1986). These mental conditioning techniques could be applied in training combat aircrews to handle the stressful environment in which they must operate.

High stress levels cause human decision-making processes to lose efficiency, and ultimately break down if they are not countered with coping strategies. Researchers have studied several methods to measure stress. In addition, psychologists have developed several techniques for managing high stress and reducing its detrimental effects on performance.

3.3.1.4 Advanced Training Systems

Training R&D is applying advanced techniques and emerging technologies such as artificial intelligence (AI), to enhance combat training. Computerized training is a promising training method, ranging from basic computerized teaching or learning devices to intelligent tutoring systems (ITSs), which are interactive and adaptive instructional systems.

The Tactical Air Command's use of the Computer-Based Instructional Training System (CBITS) is an example of a successful application of computer aided instruction to aircrew training. A CBITS station consists of a Zenith computer with a forty megabyte removable hard disk, a videodisc player and IBM InfoWindow touch-screen graphics. The CBITS will reduce the number of training hours required and will provide self-paced instruction for different skill levels. Previously, any instruction for training, such as upgrades, had to begin at the lowest knowledge level of a diverse group of students. Current CBITS aircrew courseware provides interactive and responsive instruction on F-16, F-15E, and F-111 fighters and can begin at the appropriate skill level. The courseware is contained on laserdisc and combines graphics and text with touch-screen capability. Initial topics include instrument orientation, communications, navigation, radar, weapons loading, and electronic warfare. For example, F-16 courseware provides instruction on cockpit switch functions and how to program the menu-driven computer displays. At present, the USAF has 150 videodisc-based training stations all over the United States and plans to expand availability to include every USAF fighter squadron in the world, and to expand courseware covering all fighter aircraft.

The Microcomputer Intelligence for Technical Training (MITT) system, recently developed and demonstrated for the Air Force Human Resources Laboratory (AFHRL) (Johnson et al., 1988), is an example of the application of AI to training. The MITT system uses artificial intelligence in a training aid function as opposed to a job aid. A prerequisite in developing MITT was understanding how humans process information in their problem solving behavior and the effects of training on this behavior. The MITT system provides space shuttle fuel cell diagnostic training for astronauts and flight controllers and has received favorable reviews by instructors and flight controllers at the NASA Johnson Space Center in Houston, Texas.

The Aircrew Combat Expert Simulation (ACES) effort, developed by AFHRL, is an example of artificial intelligence applied to training aircrew decision-making. The ACES system uses an artificially intelligent model that simulates pilot decision-making in air-to-air combat maneuvering. The two-year R&D effort developed a desktop training system for pilots in lead-in fighter training to interact with the model in mock combat scenarios. Students interact with ACES by selecting or allowing the expert model to select maneuvers and observing the outcomes in a simulated air-to-air environment. The model predicts the selection of an air combat maneuver given the scenario of one-versus-one engagement. Although transfer-of-training has not been specifically proven, student and instructor reaction to ACES is favorable and indicates that the training system may be useful in combat training.

Several training systems have been developed to enhance combat training. Most of these use computers in some capacity, often applying artificial intelligence. These devices provide training for a wide range of activities, from simple implementation skills (CBITS) to complex air combat decision-making skills (ACES). Research and Development (R&D) efforts are continuing to examine and develop advanced training systems which will improve combat skills training.

3.3.2 Current Research and Development

A survey of planned and continuing R&D activities was accomplished. Although the emphasis was placed on the Air Force sponsored exploratory (6.2) and advanced (6.3) development programs, a number of other sources were included. Those projects having relevance to aircrew combat preparation training were identified for further review. Many of the projects selected did not specifically involve aircrew training, but were considered to have potential in the combat preparation training issue. The following sections summarize the general trends observed during the review. More specific information on the selected projects is in Appendix E. The majority of projects selected involved investigations into the general areas of task analysis, human capabilities, training delivery devices/ methods and training management. Each of these areas of interest is discussed in the following sections.

3.3.2.1 Task Analysis

Many of the reviewed R&D projects reviewed use some form of task analysis to achieve the research objectives. In most cases, the research does not specifically examine the task analysis process, but instead performs a task analysis as a necessary step in achieving some other research objective. There are, however, two projects that specifically deal with the issue of conducting task analyses. The Part Task Training Methods project specifically examines the use of alternative task partitioning strategies in designing part task training systems. This project will provide a decision support system for designers of part task trainers. The Basic Job Skills Methodologies project identifies the problem solving skills and knowledge required by airmen to accomplish highly technical functions. The Part Task Trainer project deals with the functional breakdown of a required activity, e.g., performing weapons delivery; whereas the Basic Job Skills project defines the cognitive components of higher level decision-making, e.g., electronic component fault diagnosis.

3.3.2.2 Human Capabilities

Several R&D projects are investigating the human's capability to perceive and interpret information to improve training system development. The Visual Scene and Display Requirements project is addressing human visual and perceptual capabilities to develop simulator display resolution specifications requirements. The Sensor Scene Requirements project is evaluating the human ability to determine characteristics of ground targets as a function of image fidelity. This effort will ultimately provide infrared imagery display specifications for the design of simulator training systems. Two basic research programs are investigating human cognitive processes. The Learning Abilities Measurement Program is investigating the nature and organization of human learning abilities. The objective of this research is to increase understanding of human learning processes so that new procedures can be developed to measure learning abilities. The perceptual and Cognitive Dimensions of Pilot Behavior project is investigating the cognitive and perceptual aspects of human visual information processing. One of the desired outcomes of this research is the ability to design displays that are optimally matched to human information processing abilities.

3.3.2.3 Training Delivery Devices/Methods

The largest number of reviewed R&D activities reviewed dealt with the investigation of training devices and methods. Several projects, including the Advanced Visual Technology Display and Software Systems, the New Simulator Components and Software Systems, and the Low Fidelity Pilot Stations project, are examining new components for simulators. The objectives of these efforts are to improve the quality of simulators and to reduce the cost of acquiring them.

Another area of interest is the development of event simulation capabilities which provide greater combat realism during actual training missions without the necessity of interacting with a sophisticated training complex. The On-Board Electronic Warfare Simulator uses an electronics pod on the aircraft which interacts with the avionics subsystems through the aircraft's data bus. This system presents a realistic threat environment to the aircrew during training missions. The Embedded Training Concepts For Tactical Aircraft study is examining the feasibility of using the aircraft's on-board computers to artificially stimulate the avionics subsystem to simulate realistic responses to enemy threat systems. This concept takes advantage of advancements in aircraft avionics and control architectures to enhance the training environment.

Two projects are exploring the concept of networking a large number of simulators to create a more accurate interaction between individual elements in an integrated combat operation. The Defense Advanced Research Projects Agency's SIMNET project is addressing the issue of a combined army battlefield by networking individually manned simulators, command and control elements, and computer generated combat support and service elements. The SIMNET system creates a non-controlled battlefield environment where the elements interact realistically. The USAF has initiated a similar program to address integrated air operations. The Aircrew Combat Mission Enhancement program is investigating the feasibility and utility of networking full-fidelity aircraft simulators, low-fidelity pilot workstations, and command and control stations to create a realistic combat training environment.

The programs discussed so far dealt with methods that expose aircrews to simulated combat situations and allow them to practice combat skills without using actual aircraft. Other programs address the direct training of more fundamental human skills required to accomplish a large number of specific tasks. The Basic Job Skills Training System project is investigating the concept of training higher level decision-making skills necessary to advance to levels of increased responsibility within the aircraft maintenance career fields. A small business innovative research project, Situation Awareness Training, under the management of USAFSAM, is examining the feasibility of improving aircrew performance in target detection, recognition and identification by training the aircrew to deal with instantaneous stimuli at or near threshold values. The Training For Decision-making project is studying methods for acquiring the decision-making knowledge of expert battle managers. This knowledge base will be used to construct a computer-based learning environment for training higher level decision-making skills. The potential advantage of addressing these fundamental skills is the enhancement of the human capacity to master individual tasks and to deal with unforeseen situations.

3.3.2.4 Training Management

Two major areas of interest were noted in reviewing the R&D activities associated with training management: (1) training resources management, and (2) management of training system development.

The Advanced Training Decision System project is developing a prototype decision support system to aid individuals responsible for planning training for Air Force specialties. This project deals with high level training resource decisions made primarily at the command level. At an individual level, the Instructor's Associate For Tactical Air Command (TAC) Combat Training project is developing a decision aid for instructors. This aid will provide the instructor with evaluations of student performance and computer-assisted recommendations regarding the instructional strategy which should be followed. The Measures of Air Combat Performance project is validating and refining techniques for assessing air combat performance. The measurement of performance and diagnosis of training deficiencies are essential aspects of managing individualized training activities.

Several projects address the management of training system development. The Cost/Training Effectiveness Methodologies project is developing a database of cost versus training effectiveness relationships for use in trade-off analyses. The Training System Design Guidelines project is developing guidelines for designing training courseware that fully uses the capabilities of a given training device and integrates differing training media. The Total Training Decision Systems project is developing an expert system to guide decision making in total training systems design, management and delivery.

3.4 Future Combat Operations

This study used a twenty year horizon for forecasting changes in the combat environment. This forecast is primarily based upon a review of the Requirements Identification and Technology Assessment Summary (RIATAS) planning documents developed by the Deputy for Development Planning (XR) at the Human Systems Division (HSD). These summaries were developed to aid long range planning of human related system and technology development programs across the full range of HSD responsibilities. The intent of this forecast is not to identify specific weapon systems and operational plans, but instead to identify trends which will impact combat preparation training in the future.

3.4.1 Long Range Desired Capabilities

The first step in developing a long range projection of the combat preparation training environment is to identify the desired capabilities that form the basis for operational concept development of current and future weapon systems. The RIATAS process has identified a number of desired long range capabilities within each of the human centered mission areas. The following sections discuss those desired capabilities considered to have the most direct impact upon combat preparation training in the future. In some cases, similar desired capabilities identified in different RIATAS volumes have been grouped to reduce repetitiveness.

3.4.1.1 Improved Night and In-Weather Capabilities

Most current USAF tactical aircraft have a very limited capability to attack mobile targets at night or in adverse weather conditions. This limitation provides an opportunity for the enemy to use these periods to move ground forces and to reinforce existing positions. As the fluidity of the battlefield increases, the capability to conduct interdiction operations in all types of conditions become essential.

The USAF is developing and fielding advanced avionics systems to improve night and in-weather attack capabilities. The Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) system is being fielded to provide an improved capability to operate at night. The LANTIRN system uses infrared sensors to provide the pilot with a visual display of the terrain along the flight path. Other technologies, such as Synthetic Aperture Radar (SAR), Global Positioning Satellites (GPS), pattern matching navigation and embedded sensor systems (also called smart skin), may provide enhanced operational capabilities at night as well as in adverse weather.

In conjunction with these advanced avionics systems, improved aircrew/aircraft interfaces will ensure adequate situational awareness through improved cockpit design. Multi-Functional Displays (MFD) are beginning to find wide use in current and planned aircraft cockpits. These advanced video displays, interacting with on-board computers, allow information to be presented to the aircrew more effectively and in greater quantities than previous specialized displays. The concept of a "Glass Cockpit," a more advanced use of video displays, is currently being studied. Instead of several video displays arranged on the instrument panel, the "Glass Cockpit" concept uses a single, large display that covers the whole instrument panel. The pilot can arrange the displays, including control and performance instruments, to suit personal preferences. An even more advanced concept is the "Super Cockpit." In this concept, the avionics system generates an informational display on the pilot's helmet visor. The pilot can access necessary information while looking anywhere or he can view a complete, virtual image of the external environment. computer-generated, helmet-mounted display technology, head and eye tracking, and voice activated controls are critical parts of this cockpit configuration.

Operating an aircraft in a hostile, dynamic environment, while using only artificially generated situation displays increases the amount of information presented to the pilot. The Integrated Electronic Warfare System (INEWS), Airborne Self-Protection Jammer (ASPJ) and the PAVE PILLAR electronic architecture programs are attempts to integrate and automate the on-board electronic warfare suite to reduce pilot workload and information overload. The Defense Advanced Research Projects Agency (DARPA) is studying methods to provide the pilot with automated decision support. The Pilot's Associate program is attempting to use advanced computer techniques to relieve the pilot of many of the more menial tasks. This concept would allow the pilot to spend more time maintaining SA and making tactical decisions. Through incorporation of these advanced systems, the pilot of the future will operate effectively at night and in adverse weather.

3.4.1.2 Decreased Dependence on Main Operating Bases

Considerable concern has arisen in the past few years about the dependence of air operations on main operating bases and their increasing vulnerability to attack. Reliance on long hard-surfaced runways, logistical facilities, and maintenance capabilities are among the reasons modern aircraft are tied to major installations. Reducing this dependence has become a significant goal and is impacting technology and systems development programs.

There are ongoing and planned R&D activities, intended to enable Vertical/Short Take-Off and Landing (V/STOL) or Short Take-Off and Vertical Landing (STOVL) operations. These capabilities would reduce dependence upon the facilities associated with main operating bases by allowing the use of battle damaged runways and taxiways or dispersion of aircraft to less developed airfields. The F-15 Short Take-Off and Landing (STOL) and Maneuvering Technology Demonstrator is a current development program evaluating a number of technologies needed to provide STOL capability to existing and future airframes. Two-dimensional thrust vectoring, integrated flight/propulsion controls, high angle-of-attack aerodynamics and rough-field landing gear are a few of the advanced technologies being investigated in this program. The development of the CV-22 "Osprey" VTOL aircraft is another example of this trend.

In addition to aircraft performance enhancements, other development efforts are ongoing that will be critical in attaining reduced dependence on main operating bases. The USAF is developing more reliable aircraft system designs and improved maintenance diagnostic capabilities that will reduce the need for maintenance personnel and major repair facilities. A program to develop an on-board approach and landing aid for fighter aircraft is ongoing, and the system will be tested on the F-15 STOL Maneuvering and Technology Demonstrator. This system is an important concept because ground-based approach and landing aids may not be available at unimproved airfields or may not be properly aligned for operations from undamaged portions of battle damaged runways and taxi ways.

The Tactical Reconnaissance mission will benefit from the development of an Advanced Tactical Air Reconnaissance System (ATARS). This system will use Electro-Optical (EO) imaging technology to enable on-board review, analysis and data linking of reconnaissance data to ground stations. This capability will reduce the necessity for recovery at main operating bases for film processing and intelligence analysis.

3.4.1.3 Aircraft Operational Envelope Expansion

Effectively using portions of the flight envelope that the opponent cannot use has always been an objective in fighter aircraft design. An equally important objective is to deny the enemy superiority in any portion of the operational flight envelope. The goal is an improved capability for aircraft to operate in a new portion of the envelope without sacrificing its abilities to operate in other portions of the envelope. The quest for aircraft with larger operational envelopes is continuing. Toward this end, the USAF investigating a number of advanced technologies and plans to incorporate them in future aircraft designs, such as the Advanced Tactical Fighter (ATF).

Improved aircraft performance and maneuverability for air-to-air combat are being pursued through the development of advanced technologies. Improved materials and computer design techniques will enable development of higher thrust-to-weight ratio engines. These engines will provide future aircraft with greater excess specific thrust and improved fuel economy. High angle-of-attack aerodynamics, thrust vectoring, and integrated flight and propulsion controls are examples of technologies which will enhance aircraft capabilities in the low speed flight environments frequently encountered during close-in combat.

The other end of the operational flight envelope is also being extended. Desired improvements in sustained high speed and high altitude flight are the underlying reasons for technology developments in high mach/hypersonic aerodynamics, high thrust-to-weight ratio engines and adaptive aircraft configurations. The ATF will employ some of these technologies to obtain improved supersonic flight capabilities while maintaining superior maneuverability in the subsonic regions.

3.4.1.4 Enhanced Survivability and Sustainability

Survivability is enhanced by the capability to attack a target from a range that precludes defense or retaliation by the enemy. Beyond-Visual-Range (BVR) attack systems and precision-guided, standoff weapons are being developed to provide this capability. The Joint Tactical Information Distribution System (JTIDS), noncooperative Identification Friend, Foe, or Neutral (IFFN), and space-based surveillance systems are currently being developed or are planned for development in the near future. These systems will enhance the pilot's awareness of the battle situation. Coupling these advanced command and control capabilities with advanced air-to-air missiles will allow engaging multiple airborne targets at extended ranges.

The ability to operate in an air-to-ground attack environment will benefit from similar R&D activities. The Joint Surveillance and Target Attack System (JSTARS) will provide a significant improvement in command and control of battlefield air support. Advanced weapon systems, such as the Joint Tactical Missile System (JTACMS) and the Autonomous High Value Target Weapon (AHVTW) will allow the attack of targets by aircraft from ranges beyond the high-threat, terminal defense area.

Advanced aircraft system designs will also improve survivability and sustainability in a future combat environment. Automatic system reconfiguration will identify and isolate system failure or damage reroute circuitry to provide continued system operation, although in a degraded mode. Self-repairing or adaptive flight controls and fail-soft or fault-tolerant electronic architectures are examples of this technology currently being investigated. In the future, these capabilities will allow damaged aircraft, which would otherwise be lost, to continue a mission or return home.

3.4.2 System and Operational Trends

Understanding the future [illegible]ing environment is essential to channel research and choose wisely among alternative development program options. In defining this environment, the generalization of system and operational trends from specific long range goals, weapon system R&D activities, and geopolitical changes is useful. The following sections examine these trends.

3.4.2.1 System Trends

Aircraft performance has steadily improved in the past and this trend will continue. Materials technologies are making higher performance engines and lighter structures possible. Advanced aerodynamic designs allow operations at higher angles-of-attack and higher sustained airspeeds. Increased aircraft performance, coupled with advanced avionics and flight control systems, will continue the trend toward improved aircraft flexibility. Aircraft of the future will be capable of a wider spectrum of missions due to expanded operational envelopes and the ability to rapidly reconfigure aircraft systems to meet specific mission demands. This trend toward increased flexibility will be accelerated by the use of multiple flight modes, such as post stall maneuverability, direct force control and STOL capabilities. The ease of change afforded by the use of computer technology in mechanically controlled systems and in reducing the high cost of new aircraft development will make modification of existing aircraft more attractive. In addition, advanced systems and technologies developed for new aircraft will be retrofitted to existing airframes. These factors will increase the frequency of aircraft system modification.

Improvements in weapons will complement changes in the aircraft that deliver them. The trend in weapons development is toward more autonomous operation, enabling weapons release at greater distances from the target. The delivery aircraft thus fires the first shot and avoids enemy defenses. Advances in sensors and computer technologies, both hardware and software, are occurring at a high rate and will be steadily incorporated into new weapon designs. New weapons incorporating these advanced technologies and their required support systems will become more expensive. Constant or decreasing military budgets will result in the purchase of these weapons in limited quantities, requiring older weapons to remain in the inventory for longer periods. Consequently, aircrews of the future will have a greater diversity of weapons to deliver.

Improvements in aircraft performance and the increasing complexity of weapons will continue to stress the capability of aircrews to cope with the mental and physical demands of employing weapon systems. To address this problem, aircraft will use a greater system automation, such as the Integrated Electronic Warfare System (INEWS) which will detect the presence of a threat system, automatically activate the aircraft's electronic combat systems and inform the aircrew of optimal evasive maneuvers. In addition, decision-aiding devices will be a part of the avionics system and will assist the pilot to assimilate more situation information and make effective tactical decisions. These factors will permit the aircrew of the future to devote more time to managing the employment of the weapon system and less to its operation.

Table 3.5, on the next page, provides a summary of key system trends identified during the data collection phase of the study.

3.4.2.2 Operational Trends

Employment of weapon systems in the future will be affected by the characteristics of the weapon systems, the characteristics of potential enemy weapon systems, the national political environment, and the world geopolitical environment. The following sections examine these factors and how they are changing in order to forecast operational trends.

Increased Aircrew Performance
Increased Mission Flexibility
Greater Diversity of Weapons
Increased Automation of Piloting Tasks
Increased Use of On-board Decision Aids
Increased Frequency of System Modification

Table 3.5 - Key System Trends

Modern weapon systems are becoming more sophisticated and more lethal; they are also available to a greater number of nations. This availability has made the combat environment facing U.S. aircrews increasingly formidable and widespread. The introduction of modern weapon systems into smaller, underdeveloped nations with very different political objectives vastly complicates the problem of preparing for combat. This situation is not only expanding the geographical area where combat is likely, but is also increasing the types of conflict that may occur. Warfare with easily distinguishable enemies, well defined battlefield boundaries and well established rules-of-engagement has become rare and the prospect of having such traditional conflicts in the future is unlikely.

Employing beyond-visual-range weapons (both air-to-air and air-to-ground) will require aircrew access to current information about the intended target which may be well beyond the range of their aircraft sensors. Mission support systems, e.g., spaceborne radars, JTIDS and JSTARS, have been planned or are under development, to increase the delivery aircrews' situational knowledge. The aircrew will be required to interact frequently with these mission support systems. In addition, the aircrew may be required to coordinate with and transfer control of the weapon to other command and control assets for terminal guidance updates. The aircrews will also be required to coordinate activities with an increasing number of support assets integral to the strike force, such as electronic warfare and air defense suppression aircraft. As more weapons and mission support systems require aircrew interaction with multiple, non-collocated assets, the trend will be toward increased dependence upon large-scale, integrated operations.

Increased Dependence on Integrated Operations
Wider Spectrum of Types of Conflicts
Increased Sphere of Potential Conflict
Increased Battlefield Fluidity
Reduced Response Time
Increased Operational Window

Table 3.6 - Key Operational Trends

Improvements in all forms of battlefield vehicles have increased the mobility of combat forces and the responsiveness of their logistical support. The battlefield of the future may be characterized by a high fluidity of forces and by a poorly defined and unstable forward edge of the battle area. High battlefield mobility will reduce the available response time for air support which in turn will limit mission preparation time. Additionally, a premium will be put on the ability to conduct combat missions regardless of weather conditions or time of day.

Table 3.6 provides a summary of key operational trends identified during the data collection phase of the study.

4.0 ANALYSIS

4.1 Impacts on Combat Preparation Training

Forecasting problems in combat preparation training is possible by systematically examining current training characteristics, current training challenges, and system and operational trends described in previous sections. In determining possible impacts on combat preparation training, all of the environmental trends and their interactions should be considered. Looking at each trend individually could lead to erroneous conclusions, since other trends may enhance or eliminate a perceived impact.

4.1.1 Training Delivery

The following sections discuss the results of the systematic review of training delivery for each of the training phases.

Table 4.1 summarizes the key points from each training phase.

4.1.1.1 Knowledge

Virtually all training areas will encounter an increase in the quantity of information which needs to be assimilated, comprehended and retained by the aircrew. As aircraft are used in a broader range of missions and as they employ a wider variety of weapons, the aircrew will need to assimilate a greater volume of operational data. Each type of mission and weapon combination has its own set of procedures, limitations, and operating parameters. Similarly, dependence upon integrated operations, a broadening of the types of conflict and an expansion of the geographical area of responsibility will significantly complicate the acquisition and retention of theater specific operating procedures.

<u>KNOWLEDGE</u>
Increased Quantity of Factual Information
Increased Frequency of Training Material Updates
Reduced Need for Emphasis on Rapid and Accurate Recall
<u>TACTICAL DECISION-MAKING</u>
Increased Need for Stress Adaptation Training
Increased Complexity
Need for Training in Broader Range of Operational Situations
Increased Need for Emphasis on Accuracy and Timeliness
<u>IMPLEMENTATION</u>
Reduced Need for Refining Motor Skills
Reduced Criticality of Control Accuracy

Table 4.1 - Key training delivery impacts

The volatility of system data will increase as the modification of both U.S. and enemy weapon systems occurs more frequently. Modifications affect not only the system operating parameters and procedures, but also the choice of tactics best suited for a given situation. Broadening geographical areas of concern will further add to the quantity and volatility of intelligence information as the focus of mission support training is expanded. These changing parameters will require more frequent updates of training material.

Although both the quantity and volatility of information will increase, the use of on-board decision aids and automation of aircrew tasks will improve the accessibility of much of this information. This situation has already occurred in the weapons delivery task. The introduction of advanced fire control computers has reduced the necessity for recall of specific weapon characteristics since the computer automatically accesses needed parametric data, performs required delivery calculations and presents the results to the pilot. The aircrew will need to be sufficiently familiar with basic parameters in order to interpret displays, recognize problems and alter decision-making criteria, but will not need the depth of knowledge necessary for rapid, absolute recall.

4.1.1.2 Tactical Decision-Making

The physical and mental stresses confronting the combat aircrew of the future will be more severe than they are today. Increased aircraft performance will place the aircrew in a more rapidly changing environment, imposing higher physical and perceptual demands. The requirement to accomplish a wider variety of missions in degraded weather conditions will necessitate operating without the aid of external visual cues, and consequently increase workload and anxiety. Increased sortie generation rates made possible by an enlarged operational window and required by the rapidly changing battlefield will foster frequently changing duty cycles and will increase fatigue. To perform at maximum capacity, the aircrew must be trained to adapt to a more stressful environment which will be difficult to replicate safely.

The use of large-scale, integrated operations and advanced, beyond-visual-range weapons will require the aircrew to acquire, analyze and use a greater amount of situation information in the decision-making process. Individual aircrew decisions will affect and be affected by a larger number of external events. This situation, coupled with the increasing number of rules of engagement and the complexity of operating procedures imposed by the widening spectrum of conflict and by broadening geographical areas of responsibility, will make decision-making far more complex.

From an operational perspective, aircraft are desirable which can effectively perform many different types of missions and employ a wide variety of weapons. Unfortunately, the aircrew must be able to make appropriate tactical decisions in each of these situations or the system capability will not be realized in practice. Enhanced mission flexibility, a greater assortment of weapons and an enlarged operational window provided by future aircraft will increase the diversity of decision rules confronting the aircrew. On the surface, the use of on-board decision aids and the automation of pilot tasks would appear to reduce this problem. However, the introduction of additional levels of possible system operation increases the number of potential degraded operational modes. Additionally, future aircraft using gracefully degrading system architectures, will exhibit a larger number of system states ranging from fully capable to inoperative. Degraded operations must be anticipated in combat due to reduced maintenance attention, battle damage and the loss of required support assets. Therefore, the aircrew must be prepared to rapidly adapt to a widening range of degraded system capabilities. There is a requirement to train the aircrew to make effective, prompt decisions in a broader range of possible operational situations which increases the demand on aircrew time and training resources.

The increased lethality and performance of modern weapon systems reduces the margin for error and the time available for decision-making. At the same time, the consequences of making a mistake, in combat or during training, are becoming more costly, both in equipment and personnel. These situations will require increased emphasis on training aircrews to make rapid, accurate tactical decisions.

4.1.1.3 Implementation

The introduction of computer controlled subsystems in aircraft is rapidly changing the role of the aircrew. Aircraft subsystems are becoming more automated and the control inputs of the aircrew more removed from directly affecting the operation of the aircraft. Advanced technology subsystems, such as fly-by-wire flight controls, electronic fuel controls, and integrated flight and fire control subsystems are reducing the need for highly tuned motor-response skills. So called "seat-of-the-pants" flying, which requires a high degree of feel for the aircraft and a deft hand at the controls, is becoming a thing of the past. Aircraft are becoming easier to operate, a trend that can be expected to continue into the future. Emphasis on implementation skills and the difficulty in teaching them will be reduced as this trend continues.

Increases in aircraft performance, more fluid and hostile battlefields, and an enlargement of the operational window will combine to effectively reduce the amount of available time for aircrew responses to dynamic situations. For this reason, the ability of the aircrew to rapidly transfer commands to the aircraft will become more critical. Several technologies are being developed which will change the human interfaces with the aircraft from solely manual manipulation to an integration of manual, verbal and visual inputs. Although the need for the responsiveness of control inputs will increase in the future, advanced man-machine interface technologies promise to enhance the aircrew's capabilities. The use of more natural interface modes, such as speaking a command, may reduce the difficulty of training implementation skills.

Advances in automation and artificially intelligent control systems will continue to reduce the consequences of incorrect or poorly implemented aircrew inputs. Examples of advanced subsystem designs that reduce the consequences of pilot error are: flight control systems able to monitor aircraft status continually and inhibit to or modify potentially damaging control inputs; and electronic fuel controls able to monitor engine state to reduce engine stalls caused by improper throttle control movements. The criticality of accurate control inputs will be reduced in the future as aircraft control subsystems become more discriminating in interpreting the appropriateness of the input.

4.1.2 Training Management

One of the most significant challenges facing combat preparation training today is the lack of training airspace and specialized training ranges. This challenge is a result of continuing competition for airspace by civil aircraft, of the high cost of equipping and manning electronic combat and weapon delivery ranges, of greater public pressure to reduce noise, and of the perceived danger created by military training. These conditions do not show any sign of improving in the future. Enlarging the operational window will require more training at night and in degraded weather conditions. Greater dependence upon integrated operations will require more aircraft to participate in training events. Increased use of beyond-visual-range attack will require more training airspace. All of these factors combined will significantly increase the demand for already scarce resources. As a result, effective and efficient resource management will become more critical.

Increasing the variety of training events while holding steady or reducing the availability of training resources will require more individualized training management to ensure maximum utility of each training activity. The alternative is to increase the specialization of aircrews by training them for only a portion of the aircraft's capability. Failure to prepare aircrews for the full range of aircraft capabilities would place an increased burden on combat resource management and limit the full combat capability.

Pilots with combat experience play an important role in enhancing the skills of newer, less experienced pilots. Through one-on-one discussions and actual flight demonstrations, experienced combat pilots pass along the skills and attitudes essential to survival in combat. Unfortunately, the availability of experienced aircrews is decreasing and the nature of combat has changed significantly since they gained their combat experience. Aircrews of the future may not have the luxury of interacting with individuals who have personal knowledge of the demands and intricacies of combat operations. Consequently, aircrews will have to depend more upon individual study and group analysis among peers to gain insight into probable combat situations and environments.

Table 4.2 summarizes the key impacts on training management due to future operational and system trends.

4.2 Training System and Technology Development Needs/Roadmaps

Combat preparation training is different than training conducted in more formal settings, such as UPT or RTU. Most combat preparation within the unit is accomplished during continuation training using locally available training resources. This training is not instructor-centered and depends heavily upon peer interaction and aircrew self-analysis. Although preparing for combat is a primary task for operational units in peacetime, it is not the only demand on the aircrew's time as is the case in a formal training school environment. Therefore, training methods and devices specifically designed for formal training are not necessarily appropriate for this environment. Conversely, the following combat preparation training system recommendations may not be suitable for other training situations.

Reduced Availabilityof Training Resources
Increased Variety of Training Activities
Increased Requirements for Group Analysis
Increased Need for Individual Study

Table 4.2 - Key training management impacts

The following sections discuss three training system developments which could significantly benefit unit level combat preparation training. Each section contains a rationale for the system, descriptions of the component elements and a development roadmap. The roadmaps provide a relative sequencing of events (solid lines) and desirable interactions (cross-hatched lines) between the major elements. The sequencing is based upon the importance of each element, necessary prerequisite activities and the availability of technology. Additional information on the R&D projects mentioned in the following sections can be found in Appendix E.

4.2.1 Integrated Training Support System

For the most part, combat preparation training within the operational unit is a process of enhancing present skills rather than introducing new skills. Aircrew members achieve training objectives primarily through a combination of exposure to simulated combat situations in the aircraft and extensive interaction among peers. The availability and cost of flight time and the scarcity of needed airspace and ranges will make exposure to the actual flight environment increasingly difficult. High fidelity, full-mission simulators are not the answer because of their extremely high cost and lack of realism. There is a significant need for an integrated training support system within the unit to ensure that the maximum benefit can be derived from the limited flight time available. This system would be composed of five subsystems: (1) a visualization aiding subsystem, (2) an information storage and retrieval subsystem, (3) an event recording and replay subsystem, (4) an on-board event simulation subsystem, and (5) an alternative scenario analysis subsystem. These subsystems could be developed independently, but should be designed so that they complement each other in a building block fashion. Each of these subsystems will be discussed in the following sections.

4.2.1.1 Visualization Aiding Subsystem

Flying is a dynamic, three-dimensional activity that relies heavily upon visual cuing. Verbally describing this environment is difficult, making discussion of flight experiences among aircrews frustrating. For this reason, aircraft models, hands and blackboards are frequently used to aid in visualizing a flight situation. Each of these visual aids has significant limitations. Representing three dimensional relationships on blackboards is difficult and time consuming, and blackboards are not well suited to illustrate dynamic situations. Aircrews can use their hands and aircraft models to illustrate six degree-of-freedom relationships that change with time. However, these aids are generally restricted to demonstrating the actions of up to two aircraft and do not realistically depict aircraft dynamics. A visualization aiding subsystem is needed to support one-on-one and group discussions. This device should accept direct input from the user and illustrate a specific flight situation in a dynamic, three dimensional format in near real time with the discussion. The visual scene must be responsive to the user's input and not rely upon pre-developed scenarios. This subsystem should have the capability of recording a discussion session for replay and should offer multiple viewing perspectives, e.g., pilot's eye view, God's eye view, or third party aircraft's eye view. The objective of such a visualization aiding subsystem would be to improve the quality of verbal interaction between aircrews by supporting situation analysis, alternative exploration and problem diagnosis.

Technology is currently available to support this type of subsystem development. Adding appropriate input interfaces to the CBIT system which is being acquired by TAC for hosting computer based training applications may be sufficient to provide this capability.

4.2.1.2 Information Storage and Retrieval Subsystem

Every aspect of flying requires the recall and use of large amounts of data in the decision-making process. Required information for peacetime and combat operations is divided in to many formats and stored in many places within the unit which makes rapid access and interpretation of information for combat preparation training difficult. Usually, the aircrews do not require basic instruction in using information. Instead, they need to refresh their memory on specific data, learn new data, or relate one set of data to another, such as comparing the launch envelopes of two missiles. Centrally stored and easily retrieved information to support self study or discussions is needed.

The information storage and retrieval subsystem must be capable of presenting individual pieces of information as well as showing the relationships among sets of information. The subsystem should interface directly with the visualization aiding subsystem to support one-on-one and group discussions more effectively. It must also provide a single access point to all the factual information required for peacetime and combat operations and have sufficient safeguards to protect sensitive material.

This subsystem would not push the state-of-the-art in database capability. The primary issues would be initial development and maintenance of the necessary data and display formats.

4.2.1.3 Event Recording and Replay Subsystem

The center of all combat preparation training is the weapon system itself. The aircrew must integrate all the aspects of combat training through actual or simulated exposure to the flight environment. The amount and realism of this exposure is limited, placing greater importance on full realization of the benefits afforded by each training opportunity. The on-board video tape recorder (VTR), available on some aircraft for recording flight events for later analysis, is a valuable training device. Unfortunately, the VTR has a limited field of view, and the amount of flight time which can be recorded is restricted to only a short portion of the flight. Beyond the limited capability of the VTR, the aircrew member must use memory and notes, to reconstruct specific flight events. The capability to record flight data sufficient to reconstruct important flight events would significantly improve situation analysis and aircrew interaction. The subsystem developed to provide this capability should be compatible with the visualization aiding subsystem to allow integration of factual information and direct input for highlighting important points.

The technology necessary to support this capability is available or will be available in the near future. The On-Board Electronic Warfare Simulation (OBEWS) system, currently under development by the Munitions Systems Division (MSD), incorporates an event recording subsystem and could potentially provide this desired capability.

4.2.1.4 On-Board Event Simulation Subsystem

Inadequate training range support will continue to hamper effective combat preparation training. This deficiency is pronounced in training activities such as practicing low altitude defensive maneuvers in response to threats and refining electronic combat techniques. A capability to create realistic combat environments through on-board simulation would maximize the value of available flight time. The simulated events should respond correctly to aircrew actions to provide immediate and accurate feedback. Without feedback to the aircrew on the effectiveness of their responses to dynamic situations, much of the training value would be lost. In addition to immediate feedback, the event simulation subsystem must be compatible with the event recording and playback subsystem and the visualization aiding subsystem to allow for post mission analysis.

The OBEWS program, managed by MSD, is currently developing this capability for use in electronic combat training. Other types of event simulation, such as radar displays for BVR intercept practice, should also be examined. The Embedded Training Feasibility study, sponsored by the Aeronautical Systems Division (ASD), is investigating another method of providing this capability by using excess on-board computer capacity to artificially stimulate the avionics subsystem. The capability to generate full field-of-view simulations superimposed on the normal visual scene may be possible in the more distant future with advancements in helmet mounted display and computer image generation technologies. Simulation of a many-on-many engagement or a missile flyout on an actual training mission while experiencing the normal physiological sensations of flight may be possible.

4.2.1.5 Alternative Scenario Analysis Subsystem

Examining the consequences of alternative decisions during actual flight activities is not an easy task because it is difficult to control the massive number of environmental factors present in any complex combat situation. The capability to forecast and display the probable outcome of an alternative decision would be a valuable addition to the visualization aiding subsystem. Such a capability would allow interrupting the playback of a combat scenario to introduce an alternative decision and observe the probable outcome. These "what if" exercises would be very valuable in expanding an aircrew's experience base.

Providing this capability would likely involve the application of artificial intelligence technology. The ACES project developed a similar capability for air combat maneuver training. Using an expert system approach, an intelligent target was developed and used to support simulator studies and to develop a prototype stand alone training system. This type of expert system could provide the needed capability and would significantly expand the training benefit from each flight experience.

4.2.1.6 Development Roadmap

Figure 4.1 depicts the roadmap for the Integrated Training Support System.

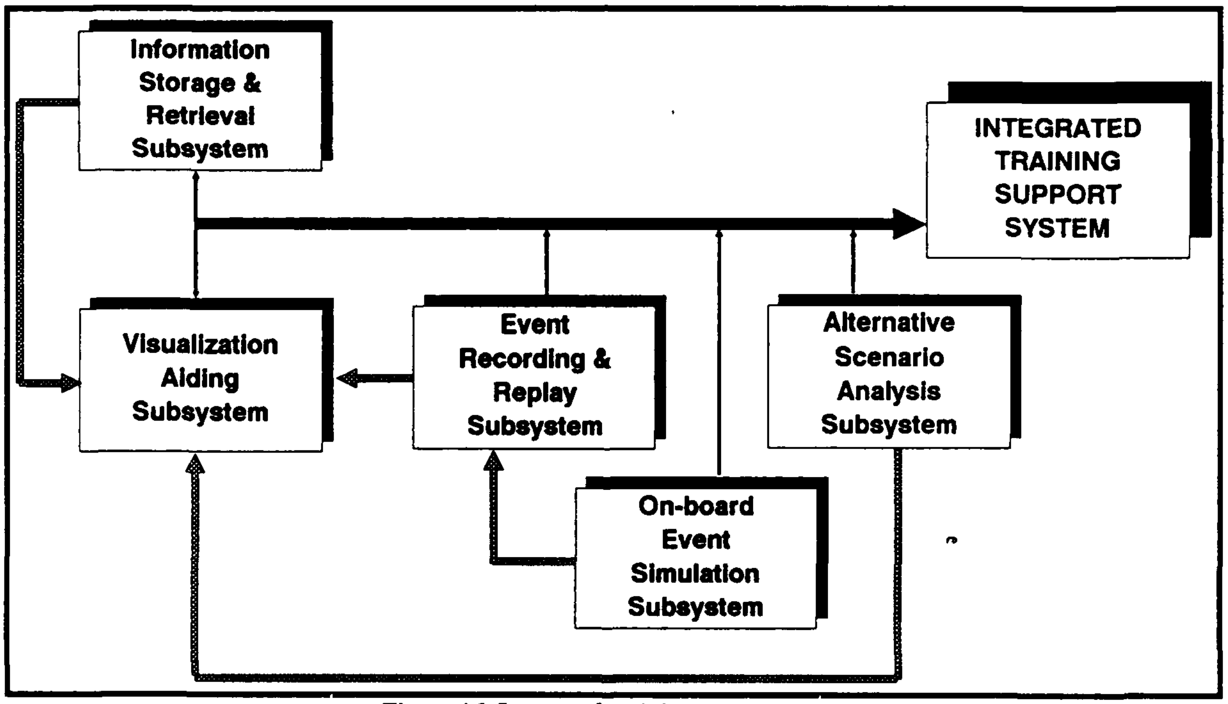

Figure 4.1-Integrated training support system

4.2.2 Tactical Decision-Making Training System

Many of the training systems under development focus on specific tasks or functions associated with employing modern aircraft in combat. These training systems range from high-fidelity, full-field-of-view simulators to low-fidelity part task trainers. They frequently combine implementation training with tactical decision-making training by allowing the aircrew to experience simulated combat events and to react in the same manner as in the actual aircraft. Use of this training approach may have distinct limitations when applied to unit combat preparation training.

The use of simulators to provide implementation training requires a relatively high degree of system fidelity. Since there are many types of aircraft used by the TAF, and often many configurations of any given aircraft within a unit, maintaining a reasonable fidelity between the simulator and the actual aircraft system can be an enormous task. Comments from the personnel interviewed in this study indicated that failure to faithfully represent the actual aircraft systems detracts from the value of simulator practice and can even result in negative training. A lack of simulator fidelity could be a distraction for the aircrews, reducing the effectiveness of simulators for tactical decision-making training.

The ability to train fundamental skills associated with tactical decision-making directly without focusing on specific functional tasks could prepare the aircrew to deal with dynamic combat situations more efficiently. Enhancing the aircrew's tactical decision-making skills would also ensure that the aircrew is ready to benefit from the limited availability of exposure to actual or high-fidelity simulated flight experiences. There are two major subsystems associated with the tactical decision-making training system being proposed: (1) a decision-making training subsystem and (2) a stress adaptation training subsystem. These subsystems are discussed in the following sections.

4.2.2.1 Decision-Making Training Subsystem

Literature on training-related research and development (R&D) activities has indicated that the manner in which aircrews make decisions is not well understood. The literature also indicated that all humans do not make decisions in the same way, and that an individual may use different decision-making strategies in different situations. Currently, the primary method of training tactical decision-making is to expose the aircrew to many different simulated combat scenarios. Given the diversity of individual aircrews and operational situations, reliance on this method alone may not be the most efficient method of enhancing decision-making skills.

There is a need to train aircrews to use decision-making strategies best suited for the highly-dynamic, stressful combat environment and to provide a training system capable of enhancing these strategies. Consequently, additional research is required to understand the best strategies for making tactical decisions in a highly-dynamic, stressful situation. One approach might be to examine the decision strategies used by successful fighter pilots, similar to the process used in the ACES project, and to construct a model of the underlying critical skills necessary to support each strategy. Once the critical cognitive and perceptual skills have been identified, methods of measuring them would be required. This effort could benefit from the LAMP program, which is developing measurement techniques to quantify critical skills associated with an individual's ability to learn. The final area of research would be to develop training techniques for enhancing the decision-making process as a whole or for enhancing a single critical skill. An example of the latter would be the enhancement of the SA portion of the decision-making process using a technique similar to that investigated in the Situation Awareness Training project.

The ultimate objective of the decision-making training subsystem is to provide concentrated, selective enhancement of critical tactical decision-making skills so that aircrews can benefit from limited flight experiences and in turn increase their chances for survival in the initial phases of combat.

4.2.2.2 Stress Adaptation Training Subsystem

Spettell and Liebert (1986) have indicated that operators may use ineffective decision-making strategies under high task demands or when task demands change suddenly, even when the operators had been taught a high-efficiency problem-solving strategy that they had successfully demonstrated under less demanding conditions. Air combat places the aircrew in a demanding and stressful environment, likely degrading decision-making skills successfully demonstrated in normal operations and training. Preparing the aircrew for high-stress environments is important to ensure that their decision-making skills remain effective.

Aircrews are trained today to function in stressful situations by creating as realistic and therefore as stressful an environment as possible during training. The Red Flag exercises and emergency procedures training in simulators are good examples of this training technique. Safety considerations during flight activities and the lack of a real threat to the aircrew in simulators impose significant limitations to this approach. The development of an alternative stress adaptation training capability would be a valuable asset in preparing aircrews to deal with the demands imposed by combat operations and peacetime emergencies.

Two general approaches could be taken to satisfy this training need. The first approach would concentrate on techniques to prepare the aircrew in advance of a known stressful mission. Sports psychologists have investigated a number of techniques to help athletes prepare for the stress expected in major competitions, e.g., the Olympics. A second approach would be to provide specific symptomatic indicators of stress related decision-making degradation to the aircrew along with corrective actions to mitigate the impact on performance. This approach is similar in concept to the recurring hypoxia prevention training provided to aircrews. The second approach may be more effective in preparing the aircrew for sudden unpredictable situation changes, such as those occurring in an emergency. The two approaches could be used singly or together to train aircrews to operate in high stress environments.

The second approach would require additional research. Kantor and Skinner (1984) provided a good overview of research conducted in predicting performance in combat environments from a psychological fitness perspective. They described a number of measurement techniques that could be used to predict psychological fitness during the initial aircrew selection process. In generally the techniques described were not well suited for real-time measurement of stress levels in flight. Further research is needed to develop symptomatic indicators of stress related decision-making degradation which the aircrew can monitor during flight. Once aware of a degraded condition, the aircrew could employ stress adaptation techniques to alleviate negative performance. Research and Development is needed to identify effective stress adaptation techniques and to develop training delivery methods.

4.2.2.3 Development Roadmap

Figure 4.2 depicts the roadmap for the Tactical Decision-Making Training System.

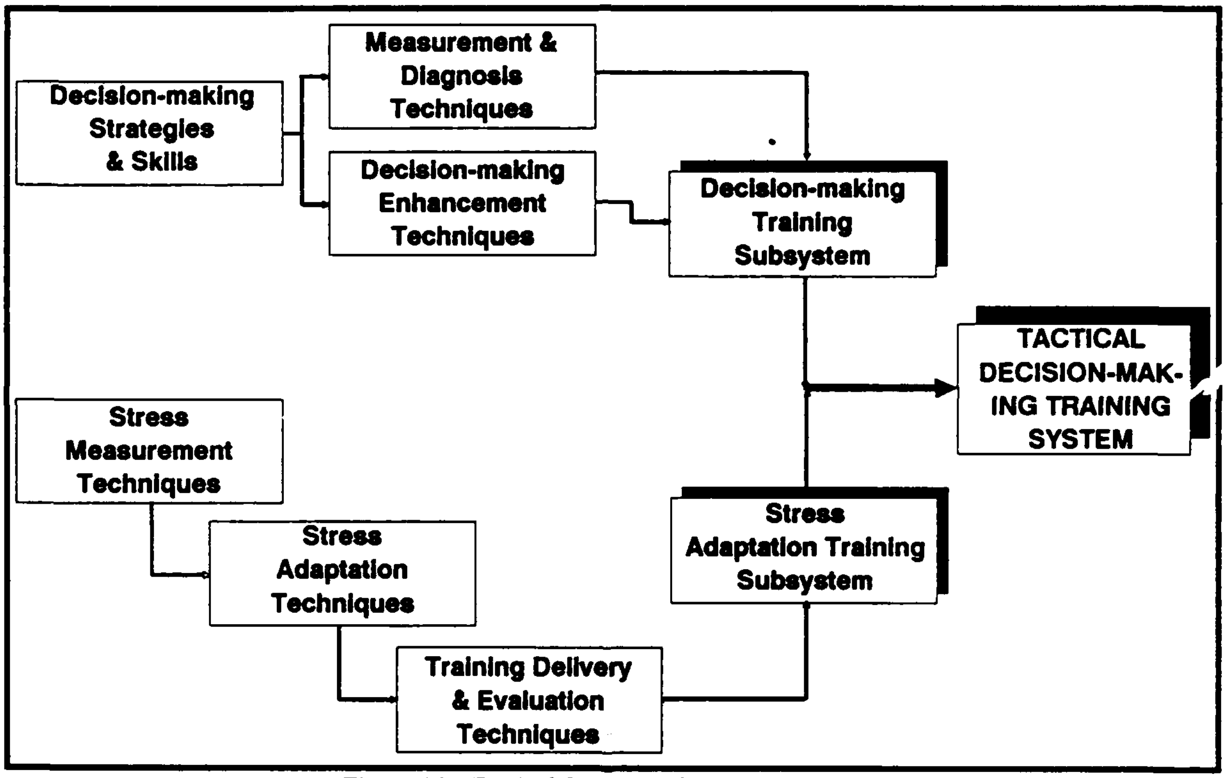

Figure 4.2 - Tactical decision-making training system

4.2.3 Proficiency-Based Training Management System

Unit level training is managed on the basis of event completion rather than on an assessment of each individual's proficiency. This method, equating proficiency to executing of a required number of training events, may not accurately determine an aircrew member's qualification due to the variable individual learning rates. For example, a crew member may complete the required events but not truly master the task. Another crew member may become proficient in less than average time and could apply the remaining time to another training task. A training management system based on actual proficiency would use an individualized approach in determining training requirements, make more efficient use of available resources, and reduce the risk of producing an inadequately prepared aircrew. The decreasing availability of flight time requires that be used as efficiently as possible to develop and maintain flying skills. A proficiency-based training management system would carefully monitor skill levels and provide training specifically to those needing it. The following sections present suggested components of a proficiency-based training management system.

4.2.3.1 Individual Performance Recordkeeping Subsystem

Recordkeeping is a vital function in a training management system. Records of an aircrew member's status must be documented and kept current to track improvement and determine training requirements. This information should be easily updated and accessible to the aircrew or instructor. There is a need for an individual performance recordkeeping subsystem to store records for monitoring progress and for determining training needs. The subsystem should store information in a logical format and should provide easily understood output. Standard performance measures used to determine an individual's proficiency level will provide this information.

Database technology is sufficiently developed to support the individual performance recordkeeping subsystem. The requirements are relatively straightforward and new technology is not necessary. For example, the Simulator Instructional Strategies project includes the development of a skill acquisition and retention database to store training information. This database will assist instructors to track progress and provide feedback for more effective training.

Performance measurement is an integral part of several ongoing USAF R&D projects. The Part Task Training Methods project and the Decision Support Systems project examine the importance and the need for performance measurement in part task training devices. The Team Training and Situational Awareness R&D project also examines the amount and kind of performance measurement and feedback appropriate for effective training. The Measures of Air Combat Performance project is developing techniques and procedures for measuring air combat performance.

4.2.3.2 Deficiency Identification and Diagnosis Subsystem

An individualized proficiency-based training management system will require accurate assessment of the

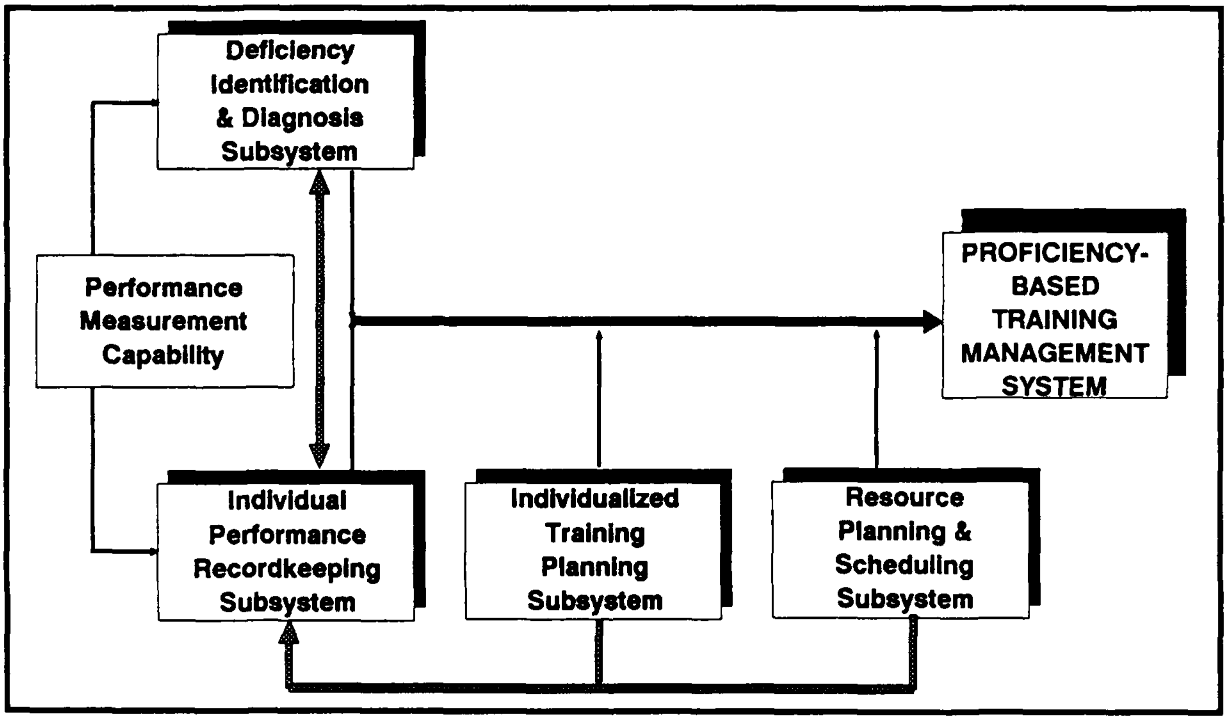

Figure 4.3 - Proficiency-based training management system

aircrew member's skill level to identify areas needing improvement. This assessment will require the development of performance measurement techniques. Performance data can then be used to determine how to achieve the desired skill level through applicable training activities. There is a requirement for a deficiency identification and diagnosis subsystem to assist the instructor or aircrew member. This subsystem should accept input on a individual' performance, identify and analyze areas needing improvement, determine the skills involved, and recommend training activities to correct the deficiencies. The subsystem should access information contained in the individual performance recordkeeping subsystem for use in this identification. The deficiency identification and diagnosis subsystem would simplify the task of dealing with the many different training needs of aircrew members within the unit. The subsystem and individual records should be accessible to the aircrew member for self-diagnosis and for maintaining individual awareness of proficiency.

Two USAF projects are cited to illustrate R&D activities which provide techniques to identify and diagnose performance deficiencies. The Measures of Air Combat Performance project validates and refines techniques for assessing air combat performance. This project will identify and implement alternative scoring techniques and collect data that reflect their relative validity. The end product will be a valid set of techniques and procedures for measuring air combat performance. Aircrews and instructors can use these measures to identify and diagnose performance deficiencies. The Instructor's Associate for Tactical Air Command Combat Training is being developed to provide instructors with evaluations of student performance and with computer-assisted recommendations on appropriate instructional strategies. This system will convert complex guidelines into simpler recommendations by explaining to the instructor why one training system or technique is better than another.

4.2.3.3 Individualized Training Planning Subsystem

After identification of an individual crew member's training needs, a plan for accomplishing the needed training must be developed. An individualized training planning subsystem could match training needs to appropriate training activities in a logical and efficient sequence. The subsystem would help develop a training plan for each aircrew member, based on current training levels, and suggest course of action to enhance proficiency.

The capability to develop individualized training strategies based upon performance indicators is the fundamental goal of the Instructor's Associate for Tactical Air Command Combat Training project. Although a portion of this project is specifically oriented toward aiding a simulator instructor, the concept may be applicable to this subsystem. Additional R&D would be required to expand the scope to include the total combat preparation training domain.

4.?.3.4 Training Resource Planning and Scheduling Subsystem

Planning and scheduling training is an important activity due to the increasing scarcity of training resources. Training managers must use available resources efficiently in order to produce and maintain the most qualified aircrews within these limitations. A training resource planning and scheduling subsystem would help ensure that training is successfully accomplished, utilizing resources efficiently while maintaining high training standards. The subsystem should use the individual training plans provided by the individualized training planning subsystem, integrate individual needs with the available resources, and develop a schedule of training activities for the unit.

The Advanced Training Decision System (TDS), the Advanced On-The-Job Training System (AOTS) and the Instructional Support System (ISS) each include a training resource management module for resource planning. However, these systems were not designed to combine short-term individualized training plans such as those envisioned as a part of a unit level proficiency based training management system. The dynamic nature of unit level scheduling may require incorporating artificial intelligence technology in this planning aid to accomplish the desired objective. Further R&D is required to satisfy this training need.

4.2.3.5 Development Roadmap

Figure 4.3 depicts the roadmap for the Proficiency-Based Training Management System.

4.3 Training System Criteria

Three systems have been recommended which could improve unit level combat preparation training. These systems were described by defining the basic capabilities they must provide rather than by the hardware and methods required to satisfy the training needs. Regardless of the specific systems developed to meet combat preparation training needs, there are some general criteria which should be considered.

The environment within an operational unit is very diverse. While considerable emphasis is placed upon enhancing and maintaining combat skills, there are many other pressures on the aircrew. Training systems introduced into the unit must build upon existing training methods and enhance them rather than simply add new training events.

A training system should foster an environment supporting the desire to learn. Simply mandating the accomplishment of training events does not ensure an efficient learning environment. By nature, combat aircrews are by nature a competitive group. Training system design should capitalize on this characteristic and, wherever possible, should incorporate competitiveness at the individual, peer and unit levels. Not only would competition promote a positive attitude, it could also prepare aircrews for the stresses of flight.

Proficiency is perishable and must be continuously maintained. Any system developed for unit combat preparation training must be readily available in sufficient quantities to prevent lost training time due to travel or backlog.

Continuation training within the unit is not generally instructor centered. Aircrews depend heavily on self analysis and peer interaction to achieve training objectives. Therefore, any system provided at the unit must be readily usable by aircrew members with an absolute minimum of assistance.

Field units limited space to accommodate training devices; furthermore assigned personnel do not have the time to learn numerous operating procedures on dissimilar training devices. The training devices provided to the unit must be integrated into a total training system to ensure efficient use of space and quality training.

Employing modern fighter aircraft in combat involves the simultaneous accomplishment of many tasks. Seldom is a single task accomplished in isolation. Training systems designed to maintain and enhance combat skills must prepare the aircrew to integrate multiple tasks successfully.

Aircraft, missions, operational concepts and weapons continuously change in an operational unit. At any given time a unit may possess several configurations of the same aircraft series. Unit training devices must be easily modified updated promptly to keep pace with aircraft modifications; only than will training devices provide accurate and effective training.

5.0 CONCLUSION

During the conduct of this analysis, a number of conclusions were reached. The most important conclusions are presented below.

Systems and operational concepts used in future combat will be significantly different from present concepts. Many of these changes will make training combat aircrews more difficult. Therefore, the USAF must improve unit combat preparation training to maintain aircrew readiness.

Unit level training presents a different environment from that of formal schools such as UPT, LIFT and RTU. The primary objectives of unit level training are maintain and enhance previously acquired skills rather than master new skills and concepts. Therefore, training concepts and devices developed for formal training situations may not be appropriate for aircrew combat preparation training at the unit.

Actual flight training experience will become less available as budget pressures and demands on airspace increase. Deriving the maximum training benefit from each flight will become more important in the future.

Providing individual and group learning tools rather than instructional delivery devices may be the best approach to aircrew combat preparation training.

The conduct of air combat involves many integrated tasks which do not occur in an easily defined sequence. Therefore, the design of training systems should enhance fundamental skills rather than concentrate on individual tasks.

Ground-based simulator training systems may not be well suited for supporting unit level training needs. The use of simulators in other training environments, such as in RTU, or as a centralized adjuncts to large scale live exercises, is more effective than their use at the unit.

Unit training systems should consist of integrated components. To optimize the use of available space and training time. The development of an aircrew combat training system must receive the same total training system design emphasis being given to the enhancement of more formal training, e.g., UPT and combat crew training schools.

Three training systems are recommended to enhance unit level combat preparation training: an integrated training support system, a tactical decision-making training system and a proficiency-based training management system. These systems should improve the efficiency of combat preparation training and place added emphasis on enhanced aircrew decision-making skills.

GLOSSARY

ACC	Alaskan Air Command
AB	Air Base
ACES	Aircrew Combat Expert Simulation
ACM	Air Combat Maneuvering
ACMI	Air Combat Maneuvering Instrumented
AFB	Air Force Base
AFHRL	Air Force Human Resources Laboratory
AHVTW	Autonomous High Value Target Weapon
AI	Artificial Intelligence
AMRAAM	Advanced Medium Range Air-to-Air Missile
ASD	Aeronautical Systems Division
ASOC	Air Support Operations Center
ASPJ	Airborne Self-Protection Jammer
ASW	Anti-Submarine Warfare
ATARS	Advanced Tactical Air Reconnaissance System
ATC	Air Training Command
ATF	Advanced Tactical Fighter
ATO	Air Tasking Order
ATS	Aircrew Training System
BVR	Beyond Visual Range
CAI	Computer-Aided Instruction
CAS	Close Air Support
CBITS	Computer-Based Instructional Training System
CFT	Cockpit Familiarization Trainer

CINCNORAD	Commander-in-Chief North American Air Defense
CRC	Control and Reporting Center
CT	Continuation Training
DARPA	Defense Advanced Researcch Projects Agency
DOC	Designed Operational Capability
ENSCE	Enemy Situation Correlation Element
EO	Electro-Optical
FEBA	Forward Edge of the Battle Area
GCC	Graduated Combat Capability
GPS	Global Positioning Satellite
HSD	Human Systems Division
IFFN	Identification Friend, Foe, or Neutral
INEWS	Integrated Electronic Warfare System
IOC	Initial Operational Capability
IQT	Initial Qualification Training
ISD	Instructional Systems Development
ITS	Intelligent Tutoring System
JCS	Joint Chiefs of Staff
JSTARS	Joint Surveillance and Target Attack System
JTACMS	Joint Tactical Missile System
JTIDS	Joint Tactical !nformation Distribution System
LANTIRN	Low Altitude Navigation and Targeting Infrared for Night
LATF	Low Altitude Tactical Formation
LSN	Local Salty Nation

MAC	Military Airlift Command
MAJCOM	Major Command
MCM	Multi-Command Manual
MFD	Multi-Functional Displays
MQF	Master Question Files
MQT	Mission Qualification Training
MR	Mission Ready
NATO	North Atlantic Treaty Organization
OBEWS	On-Board Electronic Warfare Simulator
OFT	Operational Flight Trainer
PACAF	Pacific Air Forces
PTT	Part Task Trainer
R&D	Research and Development
RIATAS	Requirements Identification and Technology Assessment Summary
RTU	Replacement Training Unit
SAR	Synthetic Aperture Radar
SA	Situation Awareness
SMART	Skills Maintenance and Reacquisition Training Research Program
SOF	Special Operations Forces
SOS	Special Operations Squadron
ST	Specialized Training
STOL	Short Take-Off and Landing
STOVL	Short Take-Off and Vertical Landing
TAC	Tactical Air Command
TACC	Tactical Air Control Center

TACFT	Tactical Aircrew Fighter Training
TACS	Tactical Air Control System
TAF	Tactical Air Forces
TFW	Tactical Fighter Wing
TOP	Target of Opportunity Program
UPT	Undergraduate Pilot Training
USAFE	United States Air Forces in Europe
USAFSAM	USAF School of Aerospace Medicine
USEUCOM	United States European Command
USPACOM	United States Pacific Commmand
V/STOL	Vertical/Short Take-Off and Landing
VTOL	Vertical Take-Off Landing
VTR	Video Tape Recorder
WST	Weapon System Trainer

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APPENDIX A

DISCUSSION OF AIR FORCE OPERATIONAL MISSIONS, TACTICAL AIR CONTROL CENTER, AND OPERATIONAL ORGANIZATIONS

A. AIR FORCE OPERATIONAL MISSIONS

The quotation marks in this section indicate extracts from Air Force Manual 1-1, Basic Aerospace Doctrine of the United States Air Force.

1. Counterair Mission

The Counterair Mission is "to gain control of the aerospace environment." The initial goal of counterair is air superiority, which means no prohibitive enemy interference. "The ultimate goal of counterair is air supremacy," which means no effective enemy interference. The counterair mission is characterized by offensive counterair, defensive counterair and suppression of enemy air defenses. Offensive counterair is conducted "...to seek out and neutralize or destroy enemy aerospace forces at a time and place of our choosing." Also, offensive counterair is "...seizing the initiative at the initiation of hostilities, conducting operations in the enemy's aerospace environment, and neutralizing or destroying the enemy's aerospace forces and supporting infrastructure."

Defensive counterair is conducted "to detect, identify, intercept, and destroy enemy aerospace forces that are attempting to attack friendly forces or penetrate friendly airspace." Defensive counterair operations "...defend friendly lines of communication, protect friendly bases, and support friendly land and naval forces while denying the enemy the freedom to carry out offensive operations."

Suppression of enemy air defenses is conducted "...to neutralize, destroy, or temporarily degrade enemy air defensive systems in a specific area by physical and/or electronic attack." The goal is to allow "...friendly aerospace forces to perform their other missions effectively without interference from enemy air defenses."

2. Air Interdiction Mission

The Air Interdiction mission is "...to delay, disrupt, divert, or destroy an enemy's military potential before it can be brought to bear effectively against friendly forces." It is normally performed at great distances from friendly surface forces. "Integrated attacks against targets in a position to have near-term effect on friendly land forces are called battlefield air interdiction."

3. Close Air Support Mission

The Close Air Support mission is "to support surface operations by attacking hostile targets close to friendly surface forces." This requires "...detailed coordination and integration with the fire and maneuver plans of friendly surface forces."

4. Special Operations Mission

The Special Operations mission is "...to influence the accomplishment of strategic or tactical objectives through the conduct of low visibility, covert, or clandestine military actions. Special operations are usually conducted in enemy controlled or politically sensitivep territories and may complement general purpose force operations."

5. Aerospace Surveillance and Reconnaissance Mission

The Aerospace Surveillance and Reconnaissance mission is "to collect information from airborne, orbital, and surface-based sensors. Surveillance operations collect information continuously from aerospace, from the earth's surface, and subsurface. Reconnaissance operations are directed toward localized or specific targets."

B. TACTICAL AIR CONTROL CENTER

The Tactical Air Control Center (TACC) is directed by a TACC Director who is responsible to the Deputy for Operations for tasking all tactical air operations. The TACC is the operations center of the Tactical Air Forces (TAF) Commander. It prepares, issues, and monitors the execution of coordinated orders for the employment of all TAFs, assigned, attached, and otherwise made available to the Commander. It is the senior control center of a Tactical Air Control System. The TAF commander through the TACC issues planning guidance to command/control elements and assigns forces. This is called the air directive and outlines the apportionment of the air effort. The TACC also develops and distributes the Air Tasking Order which translates the apportionment guidance into allocation tasking. Apportionment is the determination and assignment of the total expected effort by percentage and/or priority that should be devoted to the various air operations and/or geographic areas for a given period of time (JCS Pub I). Apportionment is a Joint Task Force Commander's decision. Allocation is the translation of apportionment into total numbers of sorties by aircraft type available for each operation or task (JCS Pub I). The allocation is a TAF/Air Component Commander decision.

1. TACC Functions and Responsibilities

The TACC functions and responsibilities are:

a. To provide centralized control.

b. To monitor current operations.

c. To plan tactical air operations.

d. To allocate air defense sorties with decentralized execution to Control and Reporting Centers (CRC).

e. To allocate immediate Close Air Support (CAS) and tactical air reconnaissance sorties.

f. To coordinate the Air Support Operations Center (ASOC) response to Army requests.

2. TACC Principle Elements

The principle elements of the TACC are the Combat Plans Division, the Combat Intelligence Division, the Combat Operations Division, and the Enemy Situation Correlation Element (ENSCE).

The Combat Plans Division of the TACC performs the air mission planning, recommends the commitment of available resources, and issues daily air tasking order (ATO). In other words Combat Plans Division plans for tomorrow's war.

The Combat Intelligence Division performs collection management, performs intelligence production, performs target intelligence, and performs data services. It also plans for tomorrow's war.

The Combat Operations Division supervises the detailed execution of daily air tasking order and monitors, coordinates and adjusts the current air operations.

The Enemy Situation Correlation Element (ENSCE) provides combat intelligence pertinent to ongoing operations from near-real-time all-source information. The Combat Operations Division and the ENSCE execute today's war.

C. OPERATIONAL ORGANIZATIONS

1. Tactical Air Command

The mission of the Tactical Air Command (TAC) is to organize, train, equip, and maintain combat-ready forces capable of rapid deployment and employment as well as ensure that strategic air defense forces are ready to meet the challenges of peacetime air superiority and wartime air defense. TAC is also charged with the responsibility of working with the Army, Navy, and Marine Corps to develop joint doctrine, procedures, tactics, techniques, training, publications, and equipment for joint operations.

Tactical Air Command supports the U.S. Pacific Command and the U.S. European Command by ensuring that its resources are adequately trained, organized, and equipped for deployment to those areas as required by various contingency plans.

Tactical Air Command's forces are organized under three numbered air forces and three major direct reporting units.

0 First Air Force, headquartered at Langley Air Force Base (AFB), VA, includes two air divisions responsible for the defense of specific geographical areas of the continental United States.

0 Ninth Air Force at Shaw AFB, SC, has ten wings performing tactical fighter operations and training as well as reconnaissance and tactical air control.

0 Twelfth Air Force at Bergstrom AFB, TX, has four air divisions and thirteen wings performing tactical fighter operations and training, reconnaissance, tactical air control, and a wide range of electronic combat tasks, including F-4G "Wild Weasel" and EF-111 "Raven" support jamming.

0 The USAF Tactical Air Warfare Center (USAFTAWC) at Eglin AFB, FL, is responsible for all aspects of electronic combat activities and provides training and evaluation of command and control and intelligence systems.

0 The USAF Tactical Fighter Weapons Center (USAFTFWC) at Nellis AFB, NV, conducts advanced training and testing in tactical air concepts, doctrine, weapons, and tactics.

0 The 28th Air Division located at Tinker AFB, OK, provides airborne warning and control and airborne jamming of enemy command, control, and communications networks.

2. Tactical Air Operations in Europe

The United States Air Forces in Europe (USAFE) is the air component of the U.S. European Command

(USEUCOM). The primary mission of USEUCOM today is to provide combat-ready forces to support the U.S. commitment to North Atlantic Treaty Organization (NATO). The purpose of these forces is to deter war by demonstrating to any potential aggressor that the costs of aggression will far outweigh any possible benefits. In addition to deterring an actual attack, however, U.S. forces also prevent the Soviets from using their military power to intimidate and coerce our European allies into an accommodation that would be contrary to the interests of freedom and democracy on both sides of the Atlantic. While the primary task is to support NATO, USEUCOM also plans for and, if necessary, conducts contingency operations in support of U.S. interests throughout a broad area. The United States Air Forces in Europe (USAFE) comprises three numbered air forces.

0 Seventeenth Air Force in Central Europe is headquartered at Sembach Air Base JAB), Federal Republic of Germany (FRG). It has among its units the 52d Tactical Fighter Wing (TFW) (F-4Gs, F-l6C/Ds) at Spangdahlem AB, FRG, the 26th Tactical Reconnaissance Wing (F-4Cs) at Zweibrucken AB, FRG, the 36th TFW (F-15A/Bs) at Bitburg AB, FRG, and the 86th TFW (F-16C/Ds) at Ramstein AB, FRG. See Appendix B for aircraft descriptions.

0 Third Air Force in the United Kingdom is headquartered at Royal Air Force (RAF) Mildenhall, United Kingdom. It has among its units the 10th TFW (A-lOAs, F-5Es) at RAF Alconbury, UK, 20th TFW (F-111Es, EF-111s) at RAF Upper Heyford, UK, 48th TFW (F-lllFs) at RAF Lakenheath, UK, and 81st TFW (A-lOAs) at RAF Bentwaters/Woodbridge, UK.

0 Sixteenth Air Force in the Southern/Mediterranean Regionis headquartered at Torrejon AB, Spain. It has among its units the 401st TFW (F-16C/Ds) at Torrejon AB, Spain.

3. Tactical Air Operations in the Pacific

The Pacific Air Forces (PACAF), with headquarters at HickamAFS, Hawaii, is the principal air arm of the U.S. Pacific Command (USPACOM). PACAFÆs primary mission is to plan, conduct, and coordinate offensive and defensive air operations in the Pacific region. The command operates 300 PACAF fighter and attack aircraft, including airsupen .rity F-15s and F-4Es, ground attack F-l6s, A-lOAs to handle tanks in Korea, RF-4s, F-Ss and OV-lOs. PACAFs region encompasses 2 billion people in 35 countries across half the world's surface. PACAF comprises three numbered air forces.

0 Fifth Air Force which is headquartered at Yokota AB,Japan has among its units the 475th Air Base Wing (UH-1Ns) and the 18th Tactical Fighter Wing (F-15s, RF-4Cs) at Kadena AS, Japan and the 432d TFW (F-l6s) at Misawa AS, Japan.

0 Seventh Air Force which is headquartered at Osan AS,Korea has among its units the 8th TFW (F-l6s) at Kunsan AS, Korea, the 51st TFW (F-4Es) at Osan AS, Korea, as well as the 25th Tactical Fighter Group (A-lOAs) at Suwon AS, Korea, and the 497 Tactical Fighter Squadron (F-4Es) at Taegu AS, Korea.

0 Thirteenth Air Force is headquartered at Clark AS,Philippines and has among its units the 3rd TFW (F-4E/Gs, F-5Es).

4. Tactical Air Operations in Alaska

The Alaskan Air Command (AAC) provides, trains, and equipstactical air forces to preserve the national sovereignty of United States lands, waters, and airspace, and is responsible to Commander-in-Chief North American Air Defense (CINCNORAD) for the defense of North America against atmospheric attack and for accomplishing assigned operational missions. Assigned to Alaskan Air Command is the 21st TFW (F-15Cs with conformal fuel tanks allowing extended range). The 21st TFW is charged with an air superiority and strategic air defense mission for AmericaÆs first line of defense.

5. Special Operations Forces

The Military Airlift Command (MAC) is a major command of the U.S. Air Force and has as a subordinate unit the Twenty-third Air Force which is a component of the U.S. Special Operations Command. The Twentythird Air Force is MAC's only numbered Air Force with worldwide responsibility. From its headquarters at Hurl burt Field, FL, it controls Air Force special operations forces (SOF), combat rescue and recovery forces, and weather reconnaissance aircraft. Special operations may include unconventional warfare, collective security, counterterrorist operations, psychological operations, and civil affairs measures. Through the 1720th Special Tactics Group, the Twenty-third Air Force provides special operations combat control and pararescue forces trained and equipped to, provide quick-response air traffic management and pararescue/medical-survival support during short-notice, sensitive contingencies as well as during peace and war. The SOF includes MH-53J Pave Low III helicopters and the new MC-130H aircraft will augment the MC-130E force.

APPENDIX B

DATA COLLECTION FORMS AND CODES

INTERVIEW DATA SHEET

1. INTERVIEW NUMBER _____ 2. DATE ________

---

3. NAME ____

4. POSITION ______________________ 5. PHONE ____________

6. LOCATION ______________________ 7. UNIT ____________

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8. AIRCRAFT TYPE ______________________________________

9. PRIMARY MISSION ____________________________________

10. MISSION-2 ______________ 11. MISSION-3 ______________

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12. REMARKS:

TRAINING MANAGEMENT DATA SHEET

1. INTERVIEW NUMBER ____________ DATE ____________

---

2. PERCENTAGE IN MR UPGRADE ____________

3. PERCENTAGE AT LEVEL B ____________ 4. AVERAGE TIME ____________

5. PERCENTAGE AT LEVEL C ____________ 6. AVERAGE TIME ____________

LOCATION (%)	FREQUENCY	EVENTS (HRS/%)

I. WEAPONS EMPLOYMENT

7. UNIT ________	10. TRAINING ________	12. GRND ________
8. WING ________	11. EVALUATION ______	13. FLT ________
9. OTHER ________		

II. THEATER OPERATIONS

14. UNIT ________	17. TRAINING ________	19. GRND ________
15. WING ________	18. EAVALUATION ______	20. FLT ________
16. OTHER ________		

III. GENERAL MISSION

21. UNIT ________	24. TRAINING ________	26. GRND ________
22. WING ________	25. EVALUATION ______	27. FLT ________
23. OTHER ________		

IV. MISSION SUPPORT

28. UNIT ________	31. TRAINING ________	33. GRND ________
29. WING ________	32. EVALUATION ______	34. FLT ________
30. OTHER ________		

V. GENERAL FLIGHT

35. UNIT ________	38. TRAINING ________	40. GRND ________
36. WING ________	39. EVALUATION ______	41. FLT ________
37. OTHER ________		

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42. FREQUENCY OF PROGRAM EVALUATION ______________________________

43. CURRENT CHALLENGES 44. FUTURE CHALLENGES

TRAINING REQUIREMENT DATA SHEET

1. INTERVIEW NUMBER ____________ DATE ______________

---

2. TRAINING AREA ______________________________________ ( )

3. SUBJECT ____ ( )

---

11. VOLATILITY __________ ( ) 12. COMPLEXITY __________ ( )

TRAINING PHASES

	KNOWLEDGE	ASSESSMENT	IMPLEMENTATION

I. TRAINING DELIVERY

	KNOWLEDGE	ASSESSMENT	IMPLEMENTATION
MEDIUM-1	13.______( )	14.______( )	15.______( )
MEDIUM-2	16.______( )	17.______( )	18.______( )
MEDIUM-3	19.______( )	20.______( )	21.______( )
MEDIUM-4	22.______( )	23.______( )	24.______( )
% TIME	25.______( )	26.______( )	27.______( )
DIFF	31.______( )	32.______( )	33.______( )

II. TRAINING EVALUATION

	KNOWLEDGE	ASSESSMENT	IMPLEMENTATION
METHOD-1	34.______( )	35.______( )	36.______( )
METHOD-2	37.______( )	38.______( )	39.______( )
METHOD-3	40.______( )	41.______( )	42.______( )

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43. CURRENT CHALLENGES 44. FUTURE CHALLENGES

MISSION-RELATED TRAINING AREAS

1. WEAPONS EMPLOYMENT TRAINING

2. THEATRE OPERATIONS TRAINING
    - A. CERTIFICATION / VERIFICATION
    - B. MISSION PLANNING
    - C. DEPLOYMENT

3. GENERAL MISSION TRAINING
    - A. AIRCREW PROCEDURES
    - B. AIR COMBAT TRAINING
    - C. LOW ALTITUDE TRAINING
    - D. FLIGHT LEAD TRAINING

4. MISSION SUPPORT TRAINING
    - A. INTELLIGENCE
    - B. ELECTRONIC COMBAT
    - C. NUCLEAR SURETY

5. GENERAL FLIGHT TRAINING
    - A. CW
    - B. INSTRUMENT
    - C. LIFE SUPPORT
    - D. FLIGHT SAFETY

VOLATILITY OF MATERIAL

HOW FREQUENTLY DOES THE MATERIAL CHANGE?

1. HIGH - MORE THAN MONTHLY

2. MEDIUM - MONTHLY TO ANNUALLY

3. LOW - GREATER THAN ANNUALLY

COMPLEXITY OF MATERIAL

HOW DIFFICULT IS THE MATERIAL TO TEACH?

1. HIGH - TECHNICAL AND ABSTRACT

2. MEDIUM - TECHNICAL OR ABSTRACT

3. LOW - NON-TECHNICAL AND PROCEDURAL

TRAINING PHASES

KNOWLEDGE - (FACTUAL INFORMATION)

* DESCRIPTIONS
* CAPABILITIES
* LIMITATIONS
* CAUTIONS/WARNINGS

TACTICAL DECISION MAKING - (SITUATIONAL AWARENESS)

* ANALYSIS METHODS
* DECISION RULES
* RULES OF THUMB
* PRIORITIES

IMPLEMENTATION - (SYSTEM LEVEL - MISSION LEVEL)

* SYSTEM OPERATION
* SWITCHOLOGY
* TECHNIQUE
* INTERACTIONS

TRAINING DELIVERY MEDIA

1. ONE-ON-ONE DISCUSSIONS (PRE/POST FLIGHT BRIEFINGS)
2. GROUP LECTURE (BRIEFINGS)
3. VISUAL AIDS (PICTURES, GRAPHS, DRAWINGS)
4. AUDIO AIDS (TAPES, RECORDS)
5. AUDIO-VISUAL AIDS (FILMS, VIDEO TAPE)
6. REGULATIONS AND MANUALS
7. PROGRAMMED TEXT / TRAINING MANUALS
8. MOCK-UPS / ACTUAL EQUIPMENT
9. COMPUTER AIDED INSTRUCTION (CAI)
10. PART-TASK TRAINERS / SIMULATORS (PTT)
11. COCKPIT FAMILIARIZATION TRAINERS / SIMULATORS (CFT)
12. WEAPON SYSTEM TRAINER (WST)
13. OPERATIONAL FLIGHT TRAINERS / SIMULATORS (OFT)
14. FLIGHT DEMONSTRATION

PROFICIENCY EVALUATION METHODS

1. FORMAL ORAL EXAMINATIONS (BOARDS)

2. INFORMAL ORAL EXAMINATIONS (DISCUSSIONS)

3. WRITTEN EXAMINATIONS

4. COMPUTER AIDED EVALUATION

5. PROFICIENCY DEMONSTRATION - SIMULATED

6. PROFICIENCY DEMONSTRATION - ACTUAL

FREQUENCY

1. DAILY
2. WEEKLY
3. MONTHLY
4. QUARTERLY
5. SEMI-ANNUALLY
6. ANNUALLY

99. OTHER

APPENDIX C

DATA SUMMARIES

TRAINING MANAGEMENT DATA SUMMARY

TRAINING LEVEL

NO.	PERCENTAGE		
	MR UPGRADE	LEVEL B	LEVEL C
2	10	60	10
6	10	80	0
11	10	85	0
8	10	85	0
101	10	0	0
13	10	44	24
14	10	30	10

WEAPONS EMPLOYMENT

NO.	LOCATION			FREQ		EVENTS	
	UNIT	WING	OTHER	TRAIN	EVAL (HRS)	GROUND (%)	FLIGHT
2	90	5	5	1	1	70	30
3	90	6	4	1	6	40	20
4	80	10	10	1	5	60	45
5	80	15	5	1	5	50	40
11	50	50	0	2	0	0	0
8	50	50	0	2	6	80	40
101	55	0	45	3	6	6	10
13	90	10	0	1	6	20	30
14	90	10	0	2	6	12	20

THEATER OPERATIONS

NO.	LOCATION UNIT	WING	OTHER	FREQ TRAIN	EVAL (HRS)	EVENTS GROUND (%)	FLIGHT
2	100	0	0	6	6	5	0
3	95	5	0	4	4	4	95
4	95	5	0	6	4	12	10
5	75	25	0	6	3	16	10
8	90	10	0	7	7	0	100
13	95	5	0	6	6	2	2
14	100	0	0	1	5	24	90
101	50	30	20	5	99	5	0

GENERAL MISSION

NO.	LOCATION UNIT	WING	OTHER	FREQ TRAIN	EVAL (HRS)	EVENTS GROUND (%)	FLIGHT
2	80	5	15	1	5	120	30
3	100	0	0	1	6	30	70
4	70	5	25	1	5	25	60
5	75	5	20	6	5	75	70
8	90	10	1	6	0	50	90
13	95	5	0	1	6	1	40
14	100	0	0	1	6	0	75
101	60	0	40	1	6	27	80

MISSION SUPPORT

NO.	LOCATION			FREQ		EVENTS	
	UNIT	WING	OTHER	TRAIN	EVAL	GROUND (HRS)	FLIGHT (%)
2	90	0	10	2	4	120	5
3	80	20	0	1	4	35	5
4	95	5	0	1	4	50	25
5	75	25	0	1	5	50	5
8	40	60	0	2	0	50	10
13	75	25	2	5	0	55	10
14	100	0	0	1	5	0	0
101	5	95	0	6	99	4	3

GENERAL FLIGHT

NO.	LOCATION			FREQ		EVENTS	
	UNIT	WING	OTHER	TRAIN	EVAL	GROUND (HRS)	FLIGHT (%)
2	100	0	0	1	6	0	35
3	80	20	0	4	4	35	10
4	90	10	0	2	5	30	15
5	95	5	0	2	5	25	20
8	90	10	0	4	3	999	0
13	95	5	5	6	0	35	5
14	100	0	0	0	0	30	20
101	25	75	3	99	0	17	20

TRAINING REQUIREMENTS DATA SUMMARY

TRAINING PHASE: KNOWLEDGE

#	M-1	M-2	M-3	M-4	VOL	% TIME	DIFF	E-1	E-2	E-3
** AREA GENERAL FLIGHT										
2	7	5	2	11	3	50	1	5	6	2
3	6	2	0	0	3	60	3	2	5	6
6	2	3	14	0	3	75	1	6	0	0
12	1	2	0	0	3	10	3	6	0	0
13	2	3	7	0	2	50	1	2	5	6
14	2	1	0	0	3	30	2	3	2	6
** AREA GENERAL MISSION										
1	1	2	3	5	3	0	0	6	2	1
2	7	1	5	11	2	20	3	2	6	5
3	2	12	14	0	2	20	3	6	5	2
4	6	1	3	0	2	10	3	3	1	2
5	2	6	5	0	2	20	3	3	1	2
6	2	1	7	0	1	20	3	3	6	5
12	1	6	0	0	3	10	3	6	2	0
13	6	7	2	0	3	40	2	3	5	6
14	2	1	7	0	2	30	3	6	2	3
15	1	14	2	6	2	15	3	3	6	2
16	1	7	6	0	3	10	3	2	3	0
18	7	2	14	1	2	30	3	1	2	5
19	1	5	6	0	3	20	3	6	2	3
101	6	2	0	0	2	10	3	3	0	0
** AREA MISSION SUPPORT										
1	2	1	3	7	1	0	0	3	2	5
2	2	1	7	13	1	50	3	3	2	5
3	2	1	6	12	1	40	2	6	5	2
4	6	3	2	0	1	70	3	3	1	2
5	2	7	6	0	1	33	3	3	1	2
12	2	6	0	0	3	20	3	3	0	0
13	2	3	10	0	2	60	1	3	2	5
14	2	1	7	3	2	50	3	3	1	0
15	2	6	1	0	2	25	3	2	3	0
16	2	7	1	0	2	95	3	3	0	0
18	7	2	0	0	1	30	3	2	3	1
19	2	7	1	0	3	20	0	6	2	3
101	2	3	0	0	2	60	3	3	0	0

TRAINING PHASE: KNOWLEDGE (cont.)

#	M-1	M-2	M-3	M-4	VOL	% TIME	DIFF	E-1	E-2	E-3
** AREA THEATER OPS										
1	3	6	1	0	3	0	0	1	6	0
2	7	1	3	2	3	70	1	1	5	0
3	2	3	0	0	3	20	3	6	5	3
4	6	3	1	0	3	60	2	1	2	5
5	6	2	1	0	2	50	3	1	3	2
6	2	6	6	0	2	75	1	1	0	0
12	6	7	1	0	2	40	3	1	0	0
13	2	6	7	0	2	50	3	1	5	6
14	6	2	1	0	3	60	2	3	6	0
15	6	1	14	0	3	15	3	6	2	1
16	6	7	1	0	2	60	1	1	6	3
18	7	1	3	2	2	60	2	1	5	2
19	6	3	1	12	2	10	2	6	2	3
101	5	2	0	0	3	85	1	3	0	0
** AREA WEAPONS EMPLOYMENT										
1	6	2	1	7	2	0	3	2	6	3
2	7	1	2	10	2	25	3	2	3	6
3	1	2	6	12	2	10	3	0	6	5
4	6	1	2	0	1	20	3	3	1	2
5	2	1	5	0	2	20	3	3	4	1
6	2	7	0	0	2	25	3	6	3	5
12	1	3	5	11	3	20	3	3	0	0
13	2	6	0	0	2	50	3	3	1	0
14	2	1	0	0	3	15	3	6	2	0
15	1	2	6	0	2	20	3	2	6	3
16	1	14	7	2	3	10	3	3	6	2
18	2	7	1	12	2	30	2	6	2	5
19	1	2	7	0	3	25	3	6	2	0
101	6	2	0	0	2	0	3	6	2	3

TRAINING PHASE: ASSESSMENT

#	M-1	M-2	M-3	M-4	CPX	% TIME	DIFF	E-1	E-2	E-3
** AREA GENERAL FLIGHT										
2	2	1	11	10	2	30	3	5	6	2
3	14	12	1	0	3	20	1	6	5	2
6	1	13	14	7	2	20	2	6	0	0
12	1	0	0	0	3	15	2	6	0	0
13	1	8	10	0	2	30	2	5	6	0
14	12	10	0	0	3	20	3	6	5	0
** AREA GENERAL MISSION										
1	1	7	6	11	1	0	0	6	2	1
2	1	14	13	10	1	20	2	6	2	3
3	2	12	14	0	1	40	1	6	5	2
4	1	12	14	0	2	20	2	5	6	3
5	1	12	14	0	2	30	2	6	5	3
6	14	1	5	0	1	40	2	6	5	0
12	1	2	0	0	1	10	2	6	2	0
13	1	13	14	0	2	30	1	5	6	0
14	1	14	0	0	2	40	1	6	0	0
15	14	2	1	0	1	25	2	6	2	0
16	1	14	7	0	1	40	1	6	2	0
18	14	1	2	12	1	30	2	6	5	2
19	1	14	0	0	3	20	2	6	2	0
101	12	14	0	0	2	45	2	6	2	0
** AREA MISSION SUPPORT										
1	1	2	3	7	1	0	0	2	6	5
2	1	13	10	14	1	30	1	5	6	2
3	12	14	1	0	1	40	1	6	5	2
4	12	6	1	0	1	20	2	12	6	1
5	2	1	9	0	1	33	1	5	3	1
12	2	1	0	0	2	50	2	6	5	0
13	1	13	14	0	2	20	2	5	6	0
14	1	14	0	0	1	30	1	6	2	0
15	14	1	0	0	1	35	1	6	0	0
16	7	2	14	0	2	2	1	6	0	0
18	14	12	1	0	1	30	1	2	5	0
19	6	5	1	0	3	50	0	6	2	0
101	1	14	10	0	2	30	2	14	0	0
** AREA THEATER OPS										
1	0	0	0	0	3	0	0	0	0	0
2	7	1	3	2	2	20	2	1	5	0
3	12	14	0	0	3	60	1	6	5	3
4	12	1	14	0	2	30	1	1	2	5

TRAINING PHASE: ASSESSMENT (cont.)

#	M-1	M-2	M-3	M-4	CPX	% TIME	DIFF	E-1	E-2	E-3
5	2	1	6	0	2	30	2	5	1	3
6	1	6	7	0	3	15	2	5	6	0
12	1	6	7	0	1	40	1	1	0	0
13	13	1	0	0	2	30	1	1	5	6
14	1	6	12	0	1	20	1	6	12	0
15	14	1	2	0	1	45	1	6	2	0
16	6	1	14	0	1	15	3	1	6	0
18	12	1	2	14	1	35	1	1	5	2
19	12	14	1	0	3	50	1	6	2	0
101	1	14	0	0	2	5	2	3	0	0
** AREA WEAPONS EMPLOYMENT										
1	1	2	3	7	1	0	1	2	6	3
2	1	7	14	2	1	35	1	2	6	5
3	1	2	12	14	1	80	1	2	5	6
4	14	12	1	0	1	30	2	6	5	2
5	14	12	1	0	1	30	2	6	5	2
6	1	14	0	0	2	40	1	6	2	0
12	1	2	0	0	1	60	2	6	2	0
13	1	2	12	14	2	25	2	1	5	6
14	1	14	0	0	2	60	1	6	0	0
15	14	1	13	0	1	30	1	2	6	5
16	1	14	7	2	3	15	2	6	2	1
18	1	14	12	0	3	50	1	6	2	5
19	14	1	2	0	2	35	1	6	2	0
101	14	1	0	0	2	0	2	6	0	0

TRAINING PHASE: IMPLEMENTATION

#	M-1	M-2	M-3	M-4	% TIME	DIFF	E-1	E-2	E-3
** AREA GENERAL FLIGHT									
2	13	11	14	1	20	2	5	6	2
3	14	12	1	0	20	2	6	5	2
6	14	0	0	0	5	3	6	0	0
12	14	0	0	0	75	1	6	0	0
13	13	14	0	0	20	3	5	6	0
14	14	12	0	0	50	1	6	5	0
** AREA GENERAL MISSION									
1	1	7	3	0	0	0	6	2	5
2	1	14	13	11	60	1	6	5	2
3	2	12	14	0	20	2	6	5	2
4	14	12	1	0	70	1	5	6	3
5	14	12	1	0	50	1	6	5	3
6	14	5	1	0	40	1	6	5	0
12	14	0	0	0	80	1	6	2	0
13	1	14	0	0	30	3	5	6	0
14	14	0	0	0	30	2	6	0	0
15	14	1	2	0	60	1	6	2	0
16	14	1	0	0	50	2	6	2	0
18	14	12	0	0	40	1	6	5	2
19	14	0	0	0	60	1	6	2	0
101	14	0	0	0	45	1	6	0	0
** AREA MISSION SUPPORT									
1	1	2	3	7	0	0	6	2	0
2	14	13	11	2	20	2	5	6	2
3	12	14	1	0	20	3	6	5	2
4	14	12	1	0	10	1	6	5	1
5	7	9	5	0	33	2	5	3	1
12	14	1	0	0	30	1	6	5	0
13	13	14	0	0	20	3	5	6	0
14	14	0	0	0	20	2	6	0	0
15	14	1	0	0	40	2	6	0	0
16	14	0	0	0	3	2	6	0	0
18	14	1	12	0	40	2	2	6	0
19	6	5	0	0	30	0	6	2	0
101	14	10	0	0	10	1	14	0	0
** AREA THEATER OPS									
1	0	0	0	0	0	0	0	0	0
2	7	1	3	2	10	3	5	1	0
3	12	14	0	0	20	2	6	5	3
4	12	14	0	0	10	3	1	2	5

TRAINING PHASE: IMPLEMENTATION (cont.)

#	M-1	M-2	M-3	M-4	% TIME	DIFF	E-1	E-2	E-3
5	12	1	14	0	20	1	5	1	0
6	1	14	0	0	10	3	5	6	0
12	1	6	7	14	20	2	1	6	0
13	13	14	0	0	20	2	6	0	0
14	1	6	12	0	20	3	6	12	0
514	1	2	0	40	2	6	2	0	
16	1	14	0	0	25	2	6	1	0
18	12	14	0	0	5	3	6	0	0
19	14	1	12	0	40	3	6	2	0
101	14	0	0	0	10	3	14	0	0
** AREA WEAPONS EMPLOYMENT									
1	1	2	14	0	0	2	2	6	0
2	14	11	13	8	40	2	6	5	3
3	1	2	14	12	10	2	6	5	2
4	14	12	1	0	50	1	6	5	1
5	14	12	1	0	50	1	6	5	1
6	14	1	2	13	35	2	6	2	0
12	1	14	0	0	20	1	6	3	5
13	1	14	0	0	25	1	6	0	0
14	14	1	0	0	25	2	6	0	0
15	14	1	0	0	50	2	6	5	2
16	14	1	7	2	75	1	6	2	0
18	14	12	10	0	20	3	6	5	0
19	14	1	12	0	40	2	6	2	0
101	14	0	0	0	99	1	6	0	0

APPENDIX D

RELATED RESEARCH AND DEVELOPMENT ACTIVITIES

TITLE: BASIC JOB SKILLS METHODOLOGIES
PROJECT: 62205F/7719
DESCRIPTION: The objectives of this study are to determine the problem solving skills and knowledge needed by airmen and to develop diagnostic achievement tests to determine what an airman knows and then prescribe a training regime. The project uses recently developed cognitive task analysis techniques. Basic jobs skills are defined as the core knowledge and thinking processes that underlie apprenticeship competence across the most technically demanding jobs in the Air Force. They represent the components of scientific literacy needed for performance in today's high technology Air Force.

TITLE: BASIC JOB SKILLS TRAINING SYSTEM
PROJECT: 63227F/2949
DESCRIPTION: The objective of this effort is to develop basic job skills prototype training systems, consisting of a series of developmental trainers to enhance basic job skills needed to achieve competence.

TITLE: TRAINING SYSTEM DESIGN GUIDELINES
PROJECT: 62205F/1192
DESCRIPTION: The objective of this study is to formulate guidelines for designing training courseware that allow full usage of the capabilities of a given training device and aid in integrating differing media in cost-effective and training-effective ways. These guidelines will aid in the design of total training systems which coordinate all phases of training.

TITLE: VISUAL SCENE AND DISPLAY REQUIREMENTS
PROJECT: 62205F/1192
DESCRIPTION: The objective of this project is to develop criteria for tactical simulator display resolution, specifications/requirements for various levels of target detail, and visual scene requirements for training low-level flight skills.

TITLE: SENSOR SCENE REQUIREMENTS
PROJECT: 62205F/1192
DESCRIPTION: The objective of this project is to evaluate the ability of the human to determine basic characteristics of ground targets as a function of sensor image fidelity. In addition, the simulated infrared scene fidelity needed to train low-altitude terrain-following and navigation tasks will be determined.

TITLE: MULTI-COCKPIT INSTRUCTOR OPERATOR
PROJECT: 63227F/2363
DESCRIPTION: The objectives of this effort are to design the instructor operator station (IOS)and develop the modular IOS software which will interface with prototype configurations of an in-house, two to four cockpit simulator. The modular software is being developed as part of a Joint Services program and will become a standard 105 software package for aircrew simulator training.

TITLE: COST/TRAINING EFFECTIVENESS METHODOLOGIES
PROJECT: 62205F/1123
DESCRIPTION: The objective of this effort is to develop a database of cost/training effectiveness relationships for use in accomplishing cost trade off analyses. When completed, the computer model will provide a way to determine optimum points on the simulation cost versus fidelity curve.

TITLE: SIMULATOR INSTRUCTIONAL STRATEGIES
PROJECT: 62205F/1123
DESCRIPTION: The objective of this project is to design instructional techniques that will increase skill retention, optimize feedback and generally help USAF instructors conduct training effectively. Planned efforts include a skill acquisition and retention database, guidelines for optimizing feedback, and guidelines for development of combat training syllabi.

TITLE: MEASURES OF AIR COMBAT PERFORMANCE
PROJECT: 63227F/3056
DESCRIPTION: The objective of this study is to validate and refine techniques for assessing air combat performance using the Air Combat Maneuvering (ACM) Performance Measurement System (PMS) developed for the Simulator for Air-to-Air Combat (SAAC) and the Air Combat Maneuvering Instrumentation (ACMI) range. The research and development will identify and implement alternative scoring techniques and collect data that reflect the relative validity of these alternative scoring procedures. Upon completion of the PMS, work will be continued to include an Air-to-Ground PMS. The end product in 1991 will be a valid set of techniques and procedures for measuring air combat performance.

TITLE: PART TASK TRAINING METHODS AND DECISION SUPPORT SYSTEMS
PROJECT: 62205F/1123
DESCRIPTION: The objective of this study is to examine alternative task partitioning strategies used in designing the Part Task Training (PTT) System, the need for and importance of performance measurement capability as opposed to simple practice devices without performance measurement, and ways in which computer-assisted instruction techniques can be used to facilitate the PTT process. A decision support system for use by the PTT system designers will be developed and a users guide for PTT devices will be produced.

TITLE: COMBAT CREW TRAINING SCHOOL (CCTS) MODERNIZATION
PROJECT: 63221F
DESCRIPTION: The objectives of this effort are to conduct a thorough review and analysis of Air Force B-52 and KC-135 formal school training requirements and produce a functional design specification. The program will provide for the effective use of existing training media and the optimal mix of academics, ground training, and flight instruction required to produce combat ready aircrews. The total training system design will include subsystems to support program development and maintenance, instructional delivery, performance evaluation, and system management.

TITLE: TOTAL TRAINING DECISION SYSTEMS
PROJECT 62205F/1192
DESCRIPTION: The objective of this project is to develop an expert system that can be used to facilitate decisions about total training system design, management and delivery.

TITLE: INSTRUCTOR'S ASSOCIATE FOR TACTICAL AIR COMMAND (TAC) COMBAT TRAINING
PROJECT: 62205F/1192
DESCRIPTION: The objective of this project is to develop a decision aid which will provide instructors with evaluations of student performance and computer-assisted recommendations regarding what kind of instructional strategy to use next. It will convert complex guidelines into more simple recommendations by p73 explaining to the instructor why one training system or technique is considered better than another.

TITLE: NEW SIMULATOR COMPONENTS AND SOFTWARE SYSTEMS
PROJECT: 63227F/2363
DESCRIPTION: The objective of this study is to investigate new simulator components and software systems for application to Air Force simulator systems. A large number of concepts will be examined, such as the non-linear focal length projection system; a universal imaging system database for visual, infrared, and electro-optical displays; and field deployable image generators.

TITLE: ADVANCED VISUAL TECHNOLOGY DISPLAY AND SOFTWARE SYSTEMS
PROJECT: 62205F/1192
DESCRIPTION: The objective of this effort is to develop and evaluate new concepts in visual technology systems. This project has been ongoing since 1978. Current activities are oriented toward improving computer image generation (CIG) as well as enhancing visual display technology. As a result of this effort, a prototype full field-of-view dome display system for the F-16 will be integrated with the Advanced Visual Technology System's computer

image generators. The system will provide a vehicle for scientists and engineers to evaluate its training utility for tactical flight simulation.

TITLE: AIRCREW COMBAT MISSION ENHANCEMENT (ACME)
DESCRIPTION: The objective of this project is to provide cost effective simulator technology for use in situational awareness training and specific mission rehearsal practice sessions for tactical aircrews. This is a major initiative for which the Air Force Human Resources Laboratory (AFHRL) is the lead agency. The program involves developing 39 technologies and 31 advanced systems concepts. ACME will rely on continued development of collateral techniques, such as very high speed integrated circuits, helmet-mounted displays and multi-participant networks. Some of the specific projects within the ACME program are:

a. TITLE: TEAM TRAINING AND SITUATIONAL AWARENESS R&D
PROJECT: 62205F/1123
DESCRIPTION: The objective of this study is to examine a number of topics concerning methods for conducting training. Specific issues include the amount and kind of performance measurement and feedback, the use of expert systems to aid in aircrew decision-making, and preferred instructional strategies.

b. TITLE: LOW FIDELITY PILOT STATIONS
PROJECT: 62205F/1192
DESCRIPTION: The objective of this effort is to develop a spectrum of training devices for use in the ACME network. Training devices will range from high-end, full-fidelity simulators to low-end, part-task trainers.

c. TITLE: MISSION CONTROL/IOS STATIONS
PROJECT: 63227F/2363
DESCRIPTION: The objective of this project is to develop an initiation, control, measurement, briefing, and debriefing capability for the ACME system.

TITLE: TRAINING FOR DECISION MAKING
PROJECT: 62205F/3017
DESCRIPTION: The objectives of this project are to develop techniques for acquiring the decision making knowledge of expert battle managers and using this knowledge base to construct a computer-based learning environment for training higher level decision-making skills.

TITLE: KNOWLEDGE-BASED TOOLS
PROJECT: 62205F/1121
DESCRIPTION: The objective of this effort is to lower the cost of developing intelligent tutoring systems by providing software tools that will allow expert practitioners to develop the knowledge base necessary in the student module. This project is jointly-sponsored by the Army Research Institute, the Naval Training Systems Center and the Air Force Human Resources Laboratory.

TITLE: ADVANCED TRAINING DECISION SYSTEM
PROJECT: 63227F/2951
DESCRIPTION: The objective of this project is to develop a prototype decision support system to aid planners in developing training for Air Force specialties. The project will specifically address decisions about what tasks to train, and where and when to train them.

TITLE: AIR COMBAT EXPERT SIMULATION (ACES)
PROJECT: 62205F/1123
DESCRIPTION: The objective of this effort is to develop an artificial intelligence model of pilot decision making in air-to-air combat maneuvering. A desktop training system was developed in which student pilots interact with the model in mock combat scenarios to learn about conditions that call for particular maneuvers. The research

failed to show any significant improvement in performance for those that used the ACES training device. However, results from questionnaire evaluations of ACES by students and instructor pilots indicated that ACES could be useful in teaching combat maneuvering. Plans have been made to expand ACES to other aircraft and other mission tasks.

TITLE: SITUATIONAL AWARENESS TRAINING
PROJECT: SMALL BUSINESS INNOVATIVE RESEARCH PROJECT
DESCRIPTION: The objective of this study is to determine the feasibility of improving aircrew performance in target detection, recognition, and identification by training aircrews to deal with instantaneous stimuli at or near threshold values. The research showed limited but encouraging evidence of a successful transfer of training in the performance of this type of task. This project was one of several projects of a larger program called the Pilot Attribute Program. Although the Pilot Attribute Program was canceled due to funding shortfalls, the situational awareness training project continues.

TITLE: ON BOARD ELECTRONIC WARFARE SIMULATOR (AN/ASQT-22)
PROJECT: 64270F
DESCRIPTION: The objective of this project is to provide a real-time electronic combat threat simulation capability to support aircrew training. The system consists of an aircraft-mounted electronics pod and a ground station. The pod interacts with the F-16 data bus to obtain aircraft status and to display pre-programmed symbology on the aircraft threat warning display. Aircraft location and attitude are continuously compared t ı internal digital map so that threat response to defensive actions can be realistically simulated. The ground station provides a capability for developing scenarios and for replaying the training mission. The debriefing capability includes two and three dimensional display modes and allows several viewing perspectives.

TITLE: EMBEDDED TRAINING CONCEPTS FOR TACTICAL AIRCRAFT
PROJECT: 65808F
DESCRIPTION: The objective of this study is to examine the feasibility and utility of using existing aircraft computers to artificially stimulate aircraft systems, allowing simulation of threat scenarios. The intent is to generate a more realistic combat environment without relying on extensive ground based threat simulators. Internal logic programming provides real time feedback to the pilot by altering the stimulation in response to defensive actions. Post flight feedback is provided by a data sheet which contains statistical scoring data. The concept has been studied using a dome simulator and the results provided to Tactical Air Command.

TITLE: CURRENT ACQUISITION PROGRAMS
PROJECT: 64227F

a. TITLE: ADVANCED TACTICAL FIGHTER (ATF) TRAINER DESCRIPTION: This study is conducting a comprehensive analysis to develop training system concepts to meet requirements for the ATF.

b. TITLE: F-15E WEAPON SYSTEM TRAINER/F-15C/D OPERATIONAL FLIGHT TRAINER
DESCRIPTION: The objective of this effort is to produce F-15C/D operational flight trainers to a total of fourteen simulators. Begin production of the F-15E weapon system trainers.

c. TITLE: F-16 WEAPON SYSTEM TRAINER
DESCRIPTION: The objective of this effort is to procure operational flight trainers, improved digital radar land mass simulators, electronic warfare training devices, and various LANTIRN simulators.

d. TITLE: GBU-15/AGM-130 PART TASK TRAINER DESCRIPTION: The objective of this effort is to develop a part task trainer to instruct tactical weapon system officers in GBU launch and guidance tasks.

e. TITLE: LANTIRN PART TASK TRAINER

DESCRIPTION: The objective of this effort is to develop part-task trainers in F-15E and F-16 configurations to train aircrews in LANTIRN techniques and operations.

f. TITLE: MODULAR SIMULATOR DESIGN PROGRAM DESCRIPTION: This effort is exploring ways to use microcomputers and high-speed data communications in modular flight simulators.

g. TITLE: SPECIAL OPERATIONS FORCES AIRCREW TRAINING SYSTEM
DESCRIPTION: The objective of this effort is to plan for a total aircrew training system for MC-130E, MC-130H, AC-130H, and AC-130U crew members.

TITLE: SIMNET
PROJECT: Defense Advanced Research Projects Agency (DARPA)
DESCRIPTION: This project is examining the feasibility and utility of large scale interactive simulator networks for training combat skills. The project is networking a large number of manned simulators, command and control elements, and computer generated combat support and service elements to create a realistic battlefield environment. Two significant features make the SIMNET concept unique: (1) distributed simulation, and (2) interactive simulation, i.e., no controllers.

TITLE: LEARNING ABILITIES MEASUREMENT PROGRAM (LAMP)
PROJECT: 61102F/2313
DESCRIPTION: This program is investigating the nature and organization of human learning abilities with the ultimate goal of contributing to a new model-based selection and classification system. The program is defining systems for measuring fundamental human characteristics, such as information processing speed, working memory capacity, and parameters associated with factual and procedural knowledge bases. The research has contributed to a tentative model of mental skills responsible for the ability to learn. The ultimate goal of the project is the development of procedures for measuring learning abilities which will aid in the selection and classification process.

TITLE: PERCEPTUAL AND COGNITIVE DIMENSIONS OF PILOT BEHAVIOR
PROJECT: 61102F/2313
DESCRIPTION: This project is investigating two issues related to the cognitive and perceptual aspects of human visual information processing. Visual research is being conducted to examine attention shifts. The objectives of this effort are to measure the time course of attention shifts, to determine what kinds of visual information are enhanced by covert attention, to assess the effects of practice on shifting speed and information processing, and to develop a model of covert attention effects. A second major effort addresses the manner in which visual information is processed across the retina. The emphasis is on determining what aspects of a visual stimuli convey form information and how the underlying mechanisms operate, change, and interact with each other at various retinal eccentricities. The goal of this research is to provide enough understanding of the visual systems functions in the periphery so that displays can be designed which are more compatible with human information processing abilities.